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SIR HENRY BESSEMER.

WE have much pleasure in presenting our readers with the latest portrait published of Sir Henry Bessemer, the famous engineer, who coming of Breton extraction, was born at Charlton, in Hertfordshire, in 1813. Ever of an essentially inventive turn of mind, he has at various times undertaken a variety of schemes more or less intimately connected with machinery, but his name is more particularly identified with scientific improvements in the manufacture of steel, for which, as also for many other inventions, he has taken out numerous patents, until now the steel which bears his name is known the world over. The first honorary recognition of the importance of the Bessemer process in England was made by the Institution of Civil Engineers about 1858, when that body awarded to Sir Henry (then Mr.) Bessemer the gold Telford medal for a paper read by him before the members on the subject, and elected him a member of the Institute. Sweden was the next country to appreciate a process which touched so nearly upon the great staple manufacture of that country. The Bessemer process was early established there, and the Crown Prince, during the time he was president of the Iron Board of Sweden, inspected the first operation of manufacturing steel, with which he was so pleased that he at once made Mr. Bessemer an honorary member of the Iron Board. Hamburg was the next place to follow suit in adopting the process, presenting the inventor with the freedom of the city later on. Then Styria and other industrial centers of Germany adopted the manufacture, and the King of Wurtemberg presented Mr. Bessemer with a gold medal, which was accompanied with a complimentary letter of acknowledgment. In the meantime the system had been adopted at the works of Prince Demidoff and at those of the Austrian Northern Railway, near Vienna. Here the Emperor took the greatest interest in its progress, and conferred upon the inventor the honor of a Knight Commandership of the Order of Francis Joseph, the jeweled cross and crimson collar being accompanied by a complimentary letter. In 1867 a scientific commission in Paris reported to the Emperor Napoleon III. upon the progress and importance of the Bessemer process, suggesting that his Imperial Majesty should confer upon the inventor the Grand Cross of the Legion of Honor. The Emperor assented on condition that the English Minister at Paris would procure permission for Mr. Bessemer to wear it; but the requisite favor never being obtained, the honor was never conferred. At the exhibition held shortly after in the French capital, however, the Emperor personally presented Mr. Bessemer with a gold medal, weighing 12 ounces, in recognition of the value of his discoveries. Another graceful acknowledgment of the utility of the process was made in 1871 by the Iron and Steel Institute of Great Britain, which elected Mr. Bessemer as its president. The people of the United States have shown in many ways their appreciation of his services to science—one token among others being the bestowal of his name on one of the rising manufacturing cities of the South—Bessemer, Alabama. In 1872 the Albert gold medal of the Society of Arts was awarded by the Council to Mr. Bessemer, and was presented to him by the Prince of Wales, "for the eminent services rendered by him to arts, manufactures and commerce, in developing the manufacture of steel;" while scientific men will remember the ocean steamship saloon invented by him with the object of avoiding sea-sickness. This was first tested in 1875.

Sir Henry Bessemer was knighted in 1879, and among other honors which he has received in addition to those cited above are the Freedoms of the Turners' Company, the Cutters' Company, and of the City of London—this last being presented in a gold box, as the phraseology runs, but which is really a magnificent casket costing one hundred guineas—and also of the city of Hamburg; besides a fellowship of the Royal Society, and the awarding of the Howard Quinquennial prize (a large gold cup), by the Institute of Civil Engineers. Sir Henry married, in 1833, Ann, the eldest daughter of Mr. Richard Allen, of Amersham, and lives very quietly, in the enjoyment of the ample reward of his successful labors, at Denmark Hill, a very pretty southern suburb of London.—*Mech. News.*

SIR HENRY BESSEMER.

A COMPRESSED AIR DUSTER.

A WANDERING railroader has discovered at Portland, Ore., a novelty in the use of compressed air for cleaning the inside of passenger cars. In the shops of the Union Pacific at that place the passenger car yard is piped, in connection with an air-compressing plant, and at convenient intervals an ordinary garden hose with a nozzle is attached to the piping in such a way that the nozzle can be conveniently drawn into a passenger car through a window, where the air, under 50 lb. pressure, is used to blow the dust out of every possible lodging place, including the plush upholstery.

HISTORY OF BOATING ON THE MISSISSIPPI RIVER.

LAMOTHE CADILLAC, one of the early governors of Louisiana, sententiously declared: "No boat could ever be run up the Mississippi into the Wabash, the Missouri, or the Red River for any commercial or profitable purpose. As well," said he, "try to bite off a slice of the moon." According to his judgment, the rapid currents of these streams and their extreme crookedness formed insurmountable obstacles to their utility.

Very fortunately, all men are not Cadillacs. In every age adventurous spirits had endeavored to solve the problem of the navigation of the Mississippi. They had followed the light weight birch canoe of the Indian with various craft, more or less sightly, which moved over the bosoms of the grand stream and its tributaries, giving them new life.

From the bayous and interior lakes which beautify Louisiana out into the big river came the hunter with his spoils in a pirogue. This was a narrow canoe, pointed at each end, hollowed out from a single log, partly by burning, partly by hewing with an ax. Its occupant propelled it by paddling with a single paddle first on one side, then on the other. It was uncomfortable for either sitting or standing, but in the hands of an adept could cleave the waters with the swiftness of an arrow sped from the bow. The goelettes or oyster luggers sailed into the river from the bays. When they reached it their sails were furled and the oystermen cordeled them up stream. These oyster venders announced their approach is a style befitting old Neptune himself, by blowing a resonant blast on a huge pink lipped conch shell, termed by the Spaniards *boca del diavolo, i. e.*, the devil's mouth.

The radeau was a raft built of logs felled in the Louisiana swamps or on the shores of the Mississippi's upper tributaries; it was floated down by the current to New Orleans, and, having served its purpose, was sold as lumber.

The chaland, or floatboat, came from the West freighted with a cargo of salted and smoked meats, barrels of apples, flour, corn, lard, cider and whisky, dried fruits and stoneware, such as jars and crocks. As the term "flatboat" would indicate, this craft was flat bottomed like a box; on one end a tiny cabin, a mere doll house was constructed for the use of the boatmen. The chaland was assisted in floating down stream by the use of long "sweeps," or flat bladed oars, generally only one pair. Fiddling, dancing and singing varied the monotony of the boatman's mercantile venture adown the Mississippi.

The chaland a bœufs, or cattle boat, was simply a magnified flatboat having a very large cabin pierced by many windows to admit of ventilation for the animals confined within.

The caboteur, also called pirogue a voile, was a species of sailboat of good dimensions, provided with rudder and oars in addition to the sail. At one end stood a cabin occupied by occasional passengers. This style of peddling vessel carried a mixed stock in trade of groceries, wines, cordials, dry goods, and table and kitchen ware. Having made satisfactory sales of these articles they would return to their original point of departure laden with freight from the plantations. These aquatic stores would ground at convenient landing places on plantation fronts or near the villages, and were visited by all the inhabitants of the surrounding country for the purpose of barter. Not coin alone, but poultry, butter, eggs, etc., were accepted in trade. In consequence of this the negroes so frequently raided upon the hen roosts when a peddler's floating store lay convenient that the planters bestowed upon such boats the opprobrious nickname of *voleurs de volailles, i. e.*, chicken thieves.

The keelboat, called by the Louisiana creoles "la barge," was, however, the most generally accepted and comfortable river conveyance for freight, passengers, and crops of all kinds. Like the flatboats, the keelboats moved slowly, even going down stream, but the return up stream was tedious in the extreme. Flatboats were always sold at New Orleans as soon as their freight was discharged, but keelboats would return to Pittsburg, consuming from three to six months on the trip home, after having been at least six or seven weeks in going down the river. Keelboats were "light, long and narrow, sharp at both ends, and round bottomed; they were rigged with one or two 'sweeps' on each side for propelling purposes, and a sweep at one end for use as a rudder." These sweeps were rude ones of immense size, formed of young tree bodies, attached to the boat by iron pins, and having at their outer end a blade formed of thick plank or board. There were also one or two masts on the keelboats. Thus the oarsmen, of whom three were always a full complement, could run up sails when the breeze set in the proper direction and rest themselves. Setting poles were employed to free the boats from the sand bars on which they sometimes grounded, or to push them along in shallow water, and also to force them away from accumulations of driftwood and snags which interfered with their progress.

In going up stream it was found extremely difficult to overcome the force of the strong, rapid current racing downward to reach the ocean. For this warping and cordeling were resorted to. In both processes a hawser was attached to the mast. In warping, a tiny yawl was sent ahead of the keelboat, carrying with it one end of the rope; this was fastened to a tree on the river bank, and as the boatman pulled hand over hand by the rope to the tree station, a second hawser was tied to another tree further on, to which point the men then pulled the boat, and thus the warping continued, the men in the yawl knotting each rope to a tree alternately, those in the keelboat pulling up to the trees by the hawsers.

Cordeling was frequently resorted to. In this method the heavy ropes were held at one end by men on shore, who walked along laboriously dragging the boat against the current. When admissible, mules were employed instead of oarsmen, thus relieving the latter of an arduous task. This system was employed by the ancient Romans, who propelled their wheelboats by men or oxen.

There was always a contracted apartment near the stern of a keelboat, which served as its cabin. These were not only of use for giving protection to occasional passengers, but were, in many instances, the sole residences of the boat owners. Owing to this fact the latter were facetiously termed crocodiles, that is alligators, because, like these reptiles, they were equally at home on land or water.

That early travel on the Mississippi was not always a delight may easily be understood through the following announcement, published in 1797, giving due notice to possible passengers of the advantages possessed by keelboats about to leave port: "No danger need be apprehended, as every passenger will be under cover—proof against rifle and musket balls, with portholes for firing out of. Each of the boats will be armed with six pieces, carrying one pound balls, also a number of good muskets and an ample supply of ammunition. They will be strongly manned and by masters of knowledge." These warlike preparations were due to the necessity of providing protection against the attack of river pirates and savages.

Owing to its numerous difficulties and extreme inconvenience, traveling was not very customary with the fair sex of Louisiana in its early days, but the patricians of France and Spain, who had sought new homes on the wild shores of the turbulent Mississippi, knowing well the inestimable blessing of education, determined, in spite of all intervening obstacles, to procure it for their children. Their sons were sent in sailing vessels over the ocean to the time honored educational institutions of Europe, while their daughters were delegated to the seclusion of the Ursuline Convent in New Orleans. "Mademoiselle Marie" (for eleven times out of a dozen she was so baptized), with the addition of an aristocratic surname, made the trip adown the river, under the care of her father, in the rude craft of the period, feeling quite as grand as did Cleopatra

when borne in her royal barge to meet Antony. Occasionally families would make a river trip in their own boats, manned by their own slaves. They carried ample supplies of provisions, cooking utensils, bedding, awnings, etc. Tying up to the bank at night, they would build fires on the shores to frighten away the alligators coming from the river and swamp, and the wild animals from the forest, then pitch their tents, like wandering Arabs under the trees, and rest peacefully until dawn appeared.

There are many souvenirs of a romantic nature connected with travel on the Mississippi previous to its awakening by the whistle of the steamboat. The traditions of one creole family point to an ancestor who wooed his bride on a keelboat. She was a blooming, dark-eyed maiden, on her homeward trip from "Le Convent," who, to while away the tedium of the journey, chanted sweet French hymns acquired in the cloister to the notes of a guitar. The music touched the impulsive heart of the handsome fellow traveler, and "Mademoiselle Marie" never returned to the convent to assume the veil, as she had been more than half inclined to.

On another occasion a wealthy widower, a planter on the river coast, desired a governess for his charming daughters; a keelboat landed at his plantation gates; he visited it and discovered on board a family moving from the East to Louisiana; one of its members was a grown daughter, well educated and attractive. Among the household goods of the family was a piano. The planter secured the services of the young lady and the instrument for the education of his children. It is not strange, under the circumstances, that in a short while the planter was seeking another governess, while his home owned a new mistress.

The hour was approaching, however, when there would be an end to romance on keelboats; the era of steam was about to revolutionize the world. The lad Fulton had attained manhood; he had been inspired by inventive genius to perfect that steam navigation which had occupied so many minds for so long a while, and he was successful. In 1803 this young Pennsylvanian launched a small steamboat on the Seine, in 1807 he placed a second on the Hudson; gratified with his success, his ambition pointed to a still greater possible triumph on the Mississippi, although it was declared by all but a very few that it would be impossible for him to build any steamboat that could stem the strong and rapid current of the great river. Fulton turned a deaf ear to all adverse prophecies, and worked toward the end he had in view until his efforts culminated in success.

Of the various persons who have disputed Fulton's laurels as the inventor of the first perfect steamboat, Edward West's claims are the strongest. West, father of the noted painter William West, was a Virginian of Welsh extraction, who settled in Lexington, Ky., 1785, as a watchmaker, he being the first workman of that nature ever in the town. He was a serious investigator of steam and its possibilities, and constructed all the machinery for his experiments himself; among these machines was a tiny steam engine, made in 1799, and which is even yet in the museum of the lunatic asylum at Cincinnati. In August of 1801 he exhibited to the Lexingtonians a boat wherein he had applied steam to the oars; he obtained a patent for this. Its model was, unfortunately, destroyed at the burning of Washington City by the British in 1814, along with the model of his patented nail cutting machine, the first one ever invented; it cut 5,320 pounds of nails in twelve hours. West sold this patent for $10,000. It was on the Elkorn, at Lexington, that West first exhibited his boat. Disappointed at having to yield the palm of successful steamboat navigation to Fulton, he died at Lexington, August 23, 1827, aged seventy. It may be that West's claim was just, but Fulton certainly was the first one to bring steam navigation prominently before the public, the first one to make it useful for commercial and traveling purposes; in consequence of this, greatest credit will always attach to him.

While Fulton was busy working out practically his dream of steam power, many changes had occurred on the Mississippi. Louisiana had passed from the dominion of France to that of Spain, and again from the latter to that of the United States. Its name was no longer "Province of Louisiana," but "Territory of Orleans." New Orleans, its seat of government, had become an incorporated city, and the Territory itself was knocking loudly at the door of the Union demanding admission as its eighteenth State.

The Territorial Legislature of 1811, which, previous to its adjournment, received official information of the passage of the act to enable the citizens of the Territory to frame a Constitution and State government preparatory to the admission of the new State into the Union, was the identical one which also passed an act granting to Fulton and his associate, Livingston, "the sole and exclusive privilege to build, construct, make, use, employ, and navigate boats, vessels, and water craft urged or propelled through water by fire or steam, in all the creeks, rivers, bays, and waters whatever within the jurisdiction of the Territory during eighteen years from the 1st of January, 1812."

In the Clermont, which Fulton tested on the Hudson in 1809, Fulton made use of a vertical wheel invented by Nicholas J. Roosevelt, who was deeply interested in the evolution of Fulton's invention. After the acknowledged success on the Hudson, it was decided that this Roosevelt should go down the Ohio from Pittsburg, out into the Mississippi, and on down to New Orleans, studying all the way its topography, and, above all, its currents.

With this end in view, Roosevelt, accompanied by his wife and the necessary men to handle it, made the trip on a flat boat. It was in May of 1809 that Roosevelt started on his journey, making stops at Cincinnati, Louisville, and Natchez (the only towns of any note whatsoever between Pittsburg and New Orleans), and reaching New Orleans in November. At each town he had been told it would be utter madness to attempt such a feat as to overcome by steam the wild current of the Mississippi; all to whom he spoke of the joint intention of Fulton and himself to inaugurate steam travel on its turbid waters wished him well, but would depict in strong terms the impossibility of so bold a venture.

On reaching Pittsburg in January of 1810, after having consumed six months with his journey of investigation, Roosevelt made such a report that Fulton and Livingston were encouraged to start the immediate building of the pioneer steamer which was to pit its strength against the velocity of the rushing waters of the mighty river. At that period saw mills were not existent; the lumber for the boat was got out by hand and rafted down to Pittsburg, where the steamer was constructed according to the plan furnished by Fulton. It was given a 100 ton capacity, a wheel at the stern, and two masts; its length was 116 feet, its width, 20 feet; its engine was manufactured at a Pittsburg foundry, under the immediate superintendence of Roosevelt and Latrobe, and possessed a 34 inch cylinder. The boat was made comfortable by two separate cabins for passengers, that for ladies containing four berths.

Latrobe was a noted architect of his day, and in 1816 came to New Orleans to build the city water works, but failed to do so, as the city could not furnish the necessary funds.

The new boat was baptized the New Orleans, as it was intended to ply between that city and the hill town of Natchez. In the early days of September this graceful, well proportioned steam craft left Pittsburg on its experimental journey, its only passengers being Mr. and Mrs. Roosevelt and their Newfoundland dog; its crew consisted of six deck hands, a captain, a pilot, Andrew Jack by name, and Baker, the engineer, in addition to whom there were the cook, a waiter, and two maids.

The mouth of the Ohio was reached without any extraordinary event, but on entering the Mississippi it was discovered in a state of overflow. On each side the land was under water, and the pilot, who had so bravely faced the dangers of the falls at Louisville and brought the boat safely over them, was now terror stricken, for he had lost all his bearings. Everything was changed, the entire river seemed to have altered its course, whole islands marked on his chart had vanished completely, and the waters had eaten new cutoffs through the forests; but there were brave spirits aboard the New Orleans, and with trust and hope in Providence they continued cautiously on their way. Owing to the danger of attack from Indians, instead of tying up at night the boat was compelled to anchor in the stream. Even under these circumstances the savages one night endeavored to board it, and it was only by the superiority of the velocity of steam power over that of the Indian canoe paddles that the New Orleans crew escaped their wild pursuers, who were ready to attack them, even while frightened at a new craft, whose motive power, being invisible to them, filled them with awe.

One evening, in spite of their knowledge that the move was a dangerous one, the crew of the New Orleans tied her up to some trees growing on an island. During the night they were awakened by a crashing noise, and the fact that the boat was being knocked about by some mysterious agency. Imagine their surprise and fright when they discovered the island had been entirely destroyed by the flood, and the motion of the boat was caused by the timber from it being washed up against the sides of the craft and bumping it about. Gathering their scattered wits into some kind of order, the officers of the New Orleans once more started her down the river, moving with care, at a speed rate, it is said, of three miles an hour, although she is declared to have made eight miles on the Ohio. Finally the yellow, sun-baked bluffs of Natchez were sighted, and as the graceful little steamer came toward them, breasting the Mississippi current with the ease of a swan swimming over a smooth pond, all the inhabitants of the town gathered on the bluffs to view her, and wild, loud, and prolonged were the shouts which welcomed her advent. At Natchez the New Orleans received the first cotton ever carried on the waters of the Mississippi, or anywhere else, by steam, the shipper being Mr. Samuel Davis.

When the New Orleans, speeding on its way, reached that portion of the river bank above the city of New Orleans called "the coast," along which lay the plantations, all animals—domesticated and wild—rushed away from the extraordinary spectacle in amazed affright; masters and slaves quit alike their pleasure and toil to gaze in open-eyed surprise on this great wonder, this steam-breathing Queen of the Waters.

Steadily the well proportioned boat speeds down stream until the 10th of January finds the population of New Orleans flocking en masse to the levee to welcome this name-child of their prosperous city, the steamboat New Orleans.

After her warm welcome at the Crescent City the New Orleans made one trip on the Ohio, and then ran from New Orleans to Natchez until she was destroyed by fire at Baton Rouge in the winter of 1813-14. Her life was short, but she had fulfilled her destiny. New boats followed in her wake, having as commanders and pilots the flatboatmen and bargemen of former times. Cotton, which had formerly been limited in cultivation owing to the great expense of handling such heavy freight when it was compulsory to transport it on barges, now became the staple crop. In 1820 it amounted to 600,000 bales, by 1835 it had reached 1,500,000, one-half of which was sent to the New Orleans market. The population, too, increased marvelously, for men were not slow to flock to the rich lands bordering the Mississippi after the transportation of crops became facile and rapid.

The second boat sent down the Mississippi was the Vesuvius, built at Pittsburg in 1814, and enrolled at New Orleans the same year, that city being the only port where boats could be enrolled at that time, as there was no custom house at Pittsburg nor at Cincinnati. The Vesuvius was commanded by Capt. De Hart, and just prior to the fight at Chalmette Gen. Jackson took possession of her to transport arms and ammunition. She, however, was so unfortunate as to get aground, and reached New Orleans too late for the battle. Like her predecessor, she was short lived, having burned at New Orleans in 1816.

As the demands of commerce increased, new boats were supplied, until by 1820 there were fifty plying on the Mississippi, and a regular packet line was the same year established between Vicksburg and New Orleans, the first one being the Mississippi, built in New York, and placed originally on the Alabama River.

Under the steamboat system travel became a luxurious pleasure, much indulged in by the river planters especially. When a journey was undertaken a slave was stationed on the river bank to watch for the approach of a steamer; during the day he waved a white flag to signal it, during the night he burned a beacon fire on the levee and rapidly circled a blazing pine torch in the air, while in stentorian tones he cried out, "Steamboat ahoy! ahoy! ahoy!" as the boat hove into sight; a few shrill shrieks from the whistle acknowledged the signal, a bell clanged, the steamer rounded to, a gangplank was extended from the lower deck to the shore, and the traveler had begun his journey.

From 1812 until the present time there has been but one variation in the adopted method of steamboat signaling—a change which had its birth in a new era, a greater era than that of steam navigation, the era of freedom. The negro still waves the white flag and circles the blazing torch, but since 1864 the hand with which he grasps them is that of a freedman!

Of late years the steamboat trade of New Orleans is only a fraction of what it was previous to the laying of so many railoads through Louisiana and its sister States. Yet the levees and piers which extend back from the river some two hundred feet along the whole length of the city, and which in their days of infancy were mostly prized as yielding space for a pleasant promenade, are still a Babel of confusion, an anthill of industry.—*N. O. Picayune.*

PROPOSED RAILWAY THROUGH BRITISH CENTRAL AFRICA.

By Mr. W. WISEMAN, M. Inst. C. E

THE delimitation of the spheres of influence of European powers in Africa is an event of the greatest importance both to the inhabitants of that continent and of Europe. The former are now destined to conversion from a state of barbarism to one of civilization, by methods which will vary with the energy, experience, and capital which the various powers bring to bear upon their self-imposed task, and the latter will doubtless benefit commercially by the opening up of new markets for trade, and in many other ways.

England commences in this important work with a decided advantage, for she possesses experience in the civilization of barbarous races which no other country in the world possesses, and has unlimited capital at command for the development of the resources and opening up new markets for trade in her newly acquired territory; but it is to be regretted that there is a lack of energy and enterprise, especially in the engineering and commercial world, and a backwardness in embarking in the development of the vast resources of Africa, which is beyond comprehension; and one of the objects of this paper is to invite attention to the serious loss which has already resulted to English trade from this neglect of African affairs, and to the necessity for the immediate construction of railways, which of all preliminary operations is the most important, and must take precedence of all others.

The territory in central, east, and west Africa which is now British, or under British protection, is shown shaded in the accompanying map. It extends in one vast unbroken tract through Central Africa from the east to the west coast, from the gold coast to the Red Sea and Indian Ocean, excepting a small portion of Somali land, which has been allotted to Italy. The total area, inclusive of Egypt, is about 3¼ million square miles, which is greater by a quarter of a million square miles than the whole of the United States of America and about twenty-seven times greater than that of the United Kingdom. These figures will at once impress upon the reader the enormous responsibilities which have been undertaken by this country, and probably such a magnificent field for the expansion of trade will never again present itself. The contrast between the feverish anxiety displayed by this country for obtaining the largest possible share of African territory, with its undeveloped resources, and the apathy which is displayed now that it is in its possession, is simply marvelous. This country has expended much time, blood, and money in acquiring that territory, or in bringing it under its influence. But of what use is this possession, or so-called protectorate, if it neither benefits the inhabitants nor ourselves? It is satisfactory in a way to see on a map of Africa large colored patches which indicate that the territories so colored are under British influence, but there the satisfaction ends. It is true we have added much to our geographical knowledge, which is very desirable. We know the source and course of vast rivers, the position and extent of enormous fresh water lakes, forests, and mountains, the habits and peculiarities of heathen races, and we have many books written by worthy and brave travelers and explorers to entertain us; but what is now required is to turn to practicable and profitable account, both to ourselves and the miserable inhabitants of the explored districts, the information for which so much has been paid.

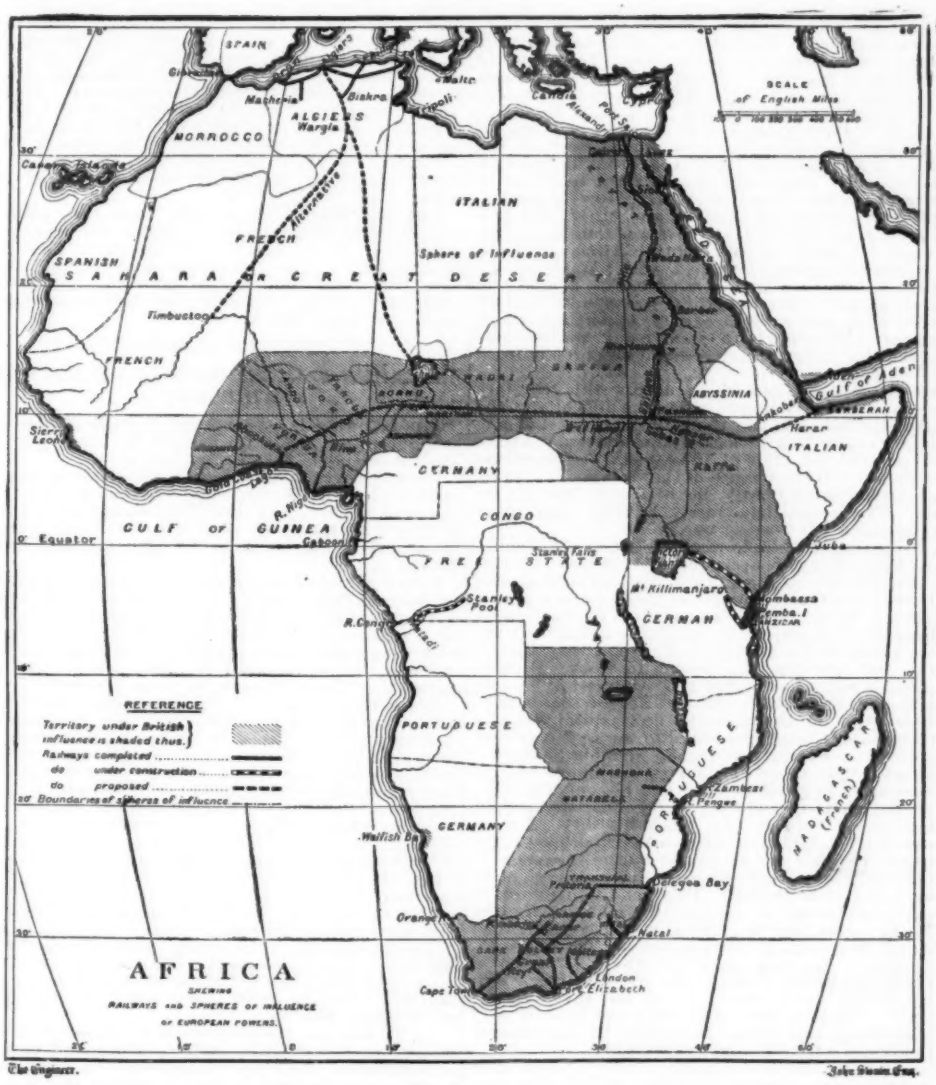
We now require means of access to those countries, and to connect them with the seaboard and the rest of the world. This, it need scarcely be said, can only be attained by railways, and I now venture to suggest a railway system for the development of British Central Africa and for opening up new markets for English goods in lieu of those which have already been lost, and others which will ere long be lost, owing to the rapid progress in manufacturing operations which other countries in all parts of the world have made, and will continue to make as their resources continue to develop. The scheme proposed is to connect the Atlantic and Indian Oceans by a railway through Central Africa, which at first sight will probably be looked upon as an impracticable scheme, or that even if it is practicable, it will not be a profitable undertaking; but it is hoped that it will be proved to be a scheme which, when its advantages, cost, expected difficulties, and financial prospects have been duly considered, is not only likely to be a practicable, but a profitable one in a high degree, and that it will commend itself to the consideration of the trading community of this country. The writer is desirous of mentioning that although he has had twenty-one years' experience in the preparation of railway projects and in the construction of railways in India, Burmah, and elsewhere, he feels that he is unable to do adequate justice to the great African railway problem, but he will be quite satisfied if this effort helps in any way toward the development of railways and British trade in Central Africa.

This proposed railway may seem to be one of unprecedented magnitude, but is eclipsed by railways already completed or proposed in other parts of the

world. There is the Canadian Pacific Railway, 2,900 miles in length, which traverses wild prairies and surmounts gigantic mountains, and which was completed in less than five years at a cost of £36,000,000. There is the Russian Railway, already commenced, which is to traverse the whole of Siberia, and connect Europe with the Pacific Ocean. Its length is estimated at about 4,800 miles, and its cost at £50,000,000. Another recent scheme is to establish railway communication between England and India, *via* France, Spain, northern Africa, Arabia, Persia, and Beloochistan to Karachi in the northwest corner of India, and another in continuation of the above to Burmah and China, which it is said will bring central China to within twenty-six days of London.

The position of the proposed Central African Railway is marked on the accompanying map by a dotted line, with its western terminus at Lagos on the slave coast, and its eastern terminus at Berberah, near the entrance to the Red Sea. Its length is estimated at 3,000 miles and its cost at £15,500,000.

Now that the delimitation of the spheres of influence in Africa of the European powers concerned has been agreed upon, the French, German, and Portuguese have lost no time in initiating a railway policy in their respective territories. The French contemplate the construction of a railway from Algiers across the Sahara Desert to the neighborhood of Lake Chad. The line would be about 1,900 miles in length, and is estimated to cost £6·65 millions sterling, or £3,500 per mile, and the annual cost of working the line at £170 per mile. It behooves the commercial community in England, and the Niger Company in particular, to give full and immediate consideration to this project and its probable results, for should it take practical effect, and the English have no counter railway policy, it will tap the trade of the western Soudan and other territories which are now under the influence of England under the Niger Company, and another opportunity of opening up new markets to English goods will be lost.



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The railway proposed by the French from Algiers to Lake Chad is shown in the accompanying map by a dotted line. The project is warmly supported by many French engineers of eminence, and it is proposed, as a preliminary measure, to establish posts along the entire route, with the object of establishing rough communication with Algeria.

The Germans also have already seen the importance and necessity for railways in their newly acquired territory, and have actually commenced the construction of a railway, which is to run from Tanga Bay into the interior as far as Mount Kilimanjaro, and will be about 223 miles in length. Its cost is estimated at £500,000, or £2,242 per mile, and its yearly working expenses at £242 per mile. The railway is shown in accompanying map as a line under construction. They also propose to establish a sanitarium at the foot of the Kilimanjaro for the railway employes and their countrymen who suffer from the effects of the climate.

The proposed railway runs through the southern portion of the Egyptian Soudan, which was lost to the Khedive owing to the Mahdist revolt. The railway would place the English government in a position to deal effectively with the Mahdist movement, and restore to Egypt not only the vast tracts of rich and fertile country over which General Gordon was governor-general, but the regions of the Upper Nile over which Egypt's influence extended, viz., almost as far as the equator and Lake Victoria Nyanza. Till this is done, it cannot be said that England has acted up to her declaration that she entered Egypt to establish the authority of the Khedive. The railway would be the means of opening to trade one of the most fertile countries in the world, and would create new markets of incalculable value for English, Indian, and colonial goods, and would confer still greater benefits upon the millions of inhabitants of Central Africa by raising them from the depths of barbarism to a state of civilization. It would also secure to England an alternative route to India and the East which would be free from all effective interference by any hostile European power or powers. It would enhance England's influence in the councils of Europe, seeing that she would be independent of the Mediterranean route for keeping open her communications with India; and under possible complications she would hold the real key of the canal by her impregnable position at the entrance to the Red Sea. It would enable England to establish and maintain a base of supplies at Berberah, the proposed eastern terminus of the railway, by which she would be in a position to act promptly in the event of a sudden demand for war material in any part of Asia.

The through route from London to Bombay, *via* the Central African Railway, would be as follows: From London by sea to the western terminus of the railway, which for the present will be assumed to be at Lagos, the distance being 5,000 miles, and average time for the voyage sixteen days. From Lagos by railway through Central Africa to Berberah, as shown by a black dotted line on the map above would be about 3,000 miles, the average time for the journey being five days. From Berberah by sea to Bombay 1,700 miles, and time six days. The total distance from London to Bombay would thus be about 9,700 miles, and time twenty-seven days. The distance from London to Bombay *via* the Mediterranean and Suez Canal is 6,500 miles, and the average time twenty-three days, hence the proposed route is only four days longer than the present route, *via* Gibraltar and the Mediterranean; but it will be seen that the object of the proposed railway is the development of Central Africa, and not to compete with the present route from England to the East in any way.

The town of Lagos, which has been selected as the western terminus, is not an exception. Lagos is situated on the slave coast, on the north side of the Lagos Lagoon, and is in the possession of the British. It is the most populous town on the west coast, containing some 50,000 inhabitants, and is already connected by a regular line of steamers with Liverpool, and is of great commercial importance.

Commencing at Lagos as the terminus, it is proposed to take the line in a northeastern direction, through the States of Yoruba and Gando as far as the town of Egga, where it would cross the Niger River. From this point the country mentioned was traversed toward Lagos by the famous traveler Gerhard Rohlfs, who in his journey describes "the transition from open and cultivated country, resembling a great garden, to undulating heights in which cultivation interchanges with woods of the oil palm. Thence, as the ocean is gradually approached, vegetation becomes more and more luxuriant, till at length a broad belt of dense primeval forest intervenes to separate the cultivated land from the sea." The inhabitants are intelligent, well clothed, and cleanly. Upon leaving Lagos, the first town of importance on the railway is Abbeokuta, with a population of 80,000. It is one of the few places in Africa where the zeal of Christian missionaries has not remained unrewarded.

The next town is Ibadan, the most populous city of Yoruba, and one of the largest in West Africa, having about 150,000 inhabitants; a very London of Negroland, with long wide streets. Goods from Tripoli, Tunis, and Egypt are here met with, and the Hausa merchants bring from Lake Chad essences, silks, natron, and torbushes, in exchange for European cloths, powder, and brandy. Further on is the town of Illori, a city of about 60,000 inhabitants, and famous as a great market throughout Western Africa. The next town along the railway is Egga, on the right bank of the Niger, which has a population estimated by travelers at from 18,000 to 50,000. This town is at present the limit of European traffic on the Niger, and has direct commerce with England. It lies in a valley ten to thirty miles in width, abounding in rich soil and cultivated fields. Here weavers rattle their shuttles in primitive looms, making a thick and durable cloth; red leather is worked up into warlike shields, and sandal makers and saddlers are busy at work.

The inhabitants a little higher up the river are said to be still more civilized, and depend upon agriculture for a living, growing indigo and dyeing the blue robes which they wear folded loosely round the body. The river Niger, near the railway crossing, is said to be about 800 yards in width, and that it is studded with islands which would probably afford facilities for erecting the railway bridge.

Across the river the line, after passing a few miles in the State of Gando, enters that of Sokoto, and following a northwest course, arrives near the town of Yakoba, which is situated on a plateau, reaching nearly 3,000 ft. in height, and which it is said would be very suitable as a residence or sanitarium for Europeans. Besides the fruits of the tropical zone, all the fruits of the southern temperate region flourish here. It is a famous place for the manufacture of cotton stuffs. At Yakoba the line changes to a direct eastern course, and after fringing the States of Bornu and Adamawa, enters that of Baghirmi, through which it passes and enters that of Wadai. Bornu is said to be a lovely and fruitful kingdom, considerably larger in extent than England, decked in all the splendor of the tropical world. The inhabitants are chiefly Mahometans. Rohlfs notices that if Bornu was in direct communication with Europe, or united to the Mediterranean by some more rapid means than that of camel caravans, which require four months to cross the desert, the greatest advantage would result to both countries. Or, why, he asks, have not the English, Germans, or French, who are most interested in supplying Africa with wares, opened out the much shorter route to Bornu by the Binnue river? Horses, cattle, asses, sheep, goats, ivory, ostrich feathers, indigo, wheat, leather, dried fish, skins of lions and leopards, and many other national products are here in vast quantity and comparatively valueless; while Bornu requires all sorts of European manufactures, such as cloth, paper, knives and razors, guns and powder, sugar and manufactured spices.

If the slave trade were abolished in Turkish dominions, the strength of Bornu would be turned to manufactures and agriculture, and its natural resources are far more than sufficient to provide it with material of exchange for everything it requires. It may here be mentioned that more slaves have been sent out of Bornu during the last twenty years than were exported in a century. Adamawa is watered by the river Chadda, the most important tributary on the left bank of the Niger. The people are very intelligent and industrious, of a yellowish red complexion, and handsome appearance. Baghirmi is watered by the river Shari, which is the most considerable stream that does not reach the sea; it flows into Lake Chad. The tribes of Baghirmi are industrious tillers of the soil, raising crops chiefly of durra and millet, which they barter for tobacco, pearls and cowry shells. Here, as well as in Bornu, we meet with entirely independent attempts at the formation of original states and social policy. There is a fully organized administration, a court and government, with its officers and a military system, and the people are skilled in many of the arts of life.

Wadai is governed by Sultan Sheikh Ally. It is watered by the periodic flowing stream of the Batha, which flows into Lake Chad. Till recently Europeans have been barred all access to this country, but Dr. Nachtigal, to whom geography is so much indebted for his discoveries in Central Africa, succeeded in crossing the country to Darfur on its eastern border, and has given us much reliable information. The line here runs through the outskirts of the great forest which was traversed by Mr. Stanley, and which is so vividly described in his most interesting work, "In Darkest Africa." The outskirts of the forest are described as resembling a light airy park, with widespread grassy tracts interspersed between the wooded parts of the land. As far as is known, there is only one important stream in Wadai which would be crossed by the railway, viz., the Salamat, which discharges itself into the Shari above referred to. The country traversed by the railway produces abundantly the silk cotton tree, palm oil, dilab bananas, pepper plants and many edible roots and virgin tobacco. It may here be mentioned that up to this point from the commencement of the railway there are many large towns of much commercial importance, situated within fifty miles of the proposed railway.

The line now enters a country which is more or less dependent upon the feudal lord, the Sultan of Wadai, and crosses an important tributary of the Shari. From this district large quantities of ivory are exported to Darbur. It now enters the Egyptian Soudan, and continues its eastern course, skirting the left bank of the Bahr-el-Homr, an important tributary of the Nile, till it reaches the Nile itself at the town of Fashoda, in N. latitude 9° 50'. After crossing the Nile, it continues its eastern direction for about 150 miles,

and here it leaves Egyptian territory, or what was formerly Egyptian territory till the Mahdist insurrection, and enters a region about which comparatively little is known.

It will be seen that the selected railway route avoids the network of streams which flow northward into the Bahr-el-Homr. It passes through much cultivated land in the Jassira Sanaar, and is not far south of the country known as the Egyptian Soudan, which is now in the hands of the Mahdists. The town of Fashoda has some 3,000 inhabitants. South of that place is the country of the Shillocks, who are a warlike race, and who, when trained, make excellent soldiers. Very little information is obtainable about the Nile in the vicinity of the railway crossing, but it is confined within well defined banks, and it is believed that a bridge with about 600 yards of waterway will be necessary. After crossing the Nile the line passes a few miles to the north of the town of Nasser, on the Sobat River. Here General Gordon established an outpost, which was afterward abandoned. In this district the papyrus is met with, and the cuckoo, king vulture, and eagle frequent these parts in large numbers. The land is alluvial and flat, the monotony of which is not broken by a single hill. It is covered with farmsteads, and is celebrated for its sheep and goats and good milk. Iron, which has a higher value than copper, is largely imported for making arms and other implements. The inhabitants are noted for their skill in the smelting of iron and in every branch of the blacksmith's trade.

Our knowledge of the country to the south of Abyssinia is, as already stated, very imperfect. It is said that centuries ago it was a Christian land. It is known to be an undulating and hilly country, but no mountains are met with. The district is now noted for its wild coffee. The line now runs along the valley of the river Hawash, and passes at a distance of fifty miles to the southeast of the town of Ankober on meadow-covered plateaus, upon which there are cotton plantations, citron groves, and strong-growing aloes. Further on, the prairie of Marar is crossed—rolling ground covered with long grass—leaving on the right the town of Harar, which is situated on the hills at a height of 5,500 ft. It is surrounded with fields and orchards, and has an estimated population of 35,000. It is essentially a commercial town, exporting ivory, tobacco, saffron, tobes—garments which resemble the Roman toga—woven cotton goods, mules, grass, honey, gums, and tallow. This town is very suitable as a residence for Europeans, and could be utilized as a retreat or a sanitarium for railway employes. Beyond the prairie a range of mountains has to be crossed, which is much cut up by deep ravines and torrent beds which lead through the hills, which would probably offer facilities for an easy and inexpensive route for the railway. The hills are said to be covered with vegetation. On their east side the ground forms into folds, and pastoral land is reached, which is covered with thick yellow grass, where camels, sheep, and goats in large numbers are tended by Somali shepherds. Finally, the hard, stoneless, alluvial coast plain is reached, through which the railway runs direct to Berberah, the selected terminus of the railway. Berberah is situated on the Somali coast, on a strip of territory which belongs to the British. It is 159 miles from Aden, and almost due south of that town. It is the only secure harbor along the northern Somali coast, and is at present capable of sheltering perhaps 500 large craft, and is safe in all winds. It is the chief outlet of the interior trade, and its annual fairs are visited by merchants from Arabia, Persia, and India, and no doubt as the railway extended its trade with the interior of Africa, the existing system would extend itself, and the port would probably become one of the most important in the East.—*The Engineer.*

To one who has even a little real knowledge of Africa the grace with which Mr. Wiseman dismisses the appalling difficulties of the problem which he sets would be tragic if there were the remotest chance of his project being undertaken. As it will be discussed during the slack season and dropped when men are busy, the lightness of his touch is one of the charms of his writing.

The line shown follows quite closely the parallel of 10° N. lat.; from Berberah, on the Gulf of Aden, to Lagos, on the Gulf of Guinea. On the same map is shown a line from Siout, in Egypt, right up the Nile valley, to intersect the east and west line at Fashoda, where it crosses the Nile, in lat. 10° N. Fashoda is actually on the west bank of the Nile and not the east, as it appears on Mr. Wiseman's map, but that is a trifle. This Nile valley line forms no essential part of the immediate scheme, but the great and obvious advantages of connecting the two are incidentally mentioned. The east and west line, which is called the Central African Railway line, is estimated by Mr. Wiseman as about 3,000 miles long. From Siout to Fashoda by the Nile is very nearly 1,800 miles; but by a railroad line, cutting off the great bends of the Nile, it might be reduced to 1,500 or 1,600.

Mr. Wiseman admits that little is known about the topography, climate, products or people of the country through which his railroad, 3,000 miles long, is to be built; but by a very simple process, viz., guessing that the conditions will average much the same as in certain Indian countries with which he is familiar, and assuming a figure of cost per mile and multiplying it by 3,000, he estimates that the Central African railroad will cost £15,500,000 for a meter gauge line and £18,000,000 for a 4 ft. 8½ in. gauge. We shall not dispute this estimate; but we have watched with interest the development of the scheme in *The Engineer*, expecting each week to be told how the enormous difficulties of a preliminary reconnaissance of the line are to be met; how, then, it is to be surveyed, located and constructed, and finally, what interest it will pay on an investment of $90,000,000. The series ends in the issue of July 31, and ends as it began, in generalities. Consequently we venture a few observations.

Only the most superficial examination of this line has ever been made, except at the point where it crosses the Nile and for a few miles from the sea at the western end. From Lagos to the proposed crossing of the Niger, say 200 miles, the country is fairly well known. Thence for 500 miles, well into Bornu, somewhat accurate information may be had. Thence, right on to the Nile, say 1,200 or 1,400 miles, the tenth parallel has been crossed by white men only at intervals of 200 to 400 miles, and from the Nile to Berberah, say 1,000 miles, the country is even less known. What may happen in 200 or 400 or 1,000 miles of Africa one may guess at, but no sane man would risk much money or reputation on the guess. To say that in those great, unknown gaps will be found materials for construction, and "teeming millions" ready to work cheaply, and hungry to trade with civilized nations, is not only pure assumption, but is absurdly improbable.

The tenth parallel is just on the border line between the country of the semi civilized Mahometans and the naked, pagan negroes. Along this line they mingle, and they flow over it north and south, the semi-civilized prevailing in one longitude and the savage in another. On the whole, the influence of the semi-civilized Mahometans is dominant enough to have slightly modified the savage conditions immediately along this parallel.

We shall not attempt to speak for the country for 700 miles from the Gulf of Guinea, to the south of Bornu. There a population may exist which is so far advanced that it will help build a railroad and will support it when built. We doubt even this; we are not sure that it would pay to build a road even 200 miles from Lagos. But to build a road from the southern part of Bornu to the Gulf of Aden, say 2,200 miles, would be an appalling and unforgivable waste of money and life.

By very far the greater part of the people are pastoral or agricultural and have few arts or handicrafts. Such as they have are the simplest and rudest. Their agriculture is confined to producing a scanty and precarious subsistence; they grow nothing that would have enough value to stand transportation, and they produce no surplus. If scarcity of rain or wars prevent making a crop, there is a local famine. The writer of these lines, in marches of thousands of miles through the Soudan, has seen this condition more than once; and we know that the Mahdist wars have been followed by famine so intense that in the great city of Khartoum the people have eaten the dead in the streets. The "doorah" and the "dokhn," which make up their breadstuffs, would have no value in European markets even if they ever grow a surplus. The gum arabic, ostrich feathers and other local products which are gathered in the whole zone that could be made tributary to the Central African railroad would not fill one freight train a week; and it would be hard to load even those trains back. People who produce so little that the world wants and want so little that the world produces may support a caravan commerce profitable to a good many traders, but from that to a commerce that would support a railroad the step is long.

One of the conditions which narrow this tributary zone and would add immensely to the difficulty of the proper exploration of the route and to the cost of construction is the lack of local transportation. At the tenth parallel the limit of the camel's usefulness has been passed. He dies south of that line and is a feeble beast on it; consequently he is seldom bred so far south. The people have rarely had the intelligence to train any other beast of burden.

As workmen the people would be worthless and uncontrollable. They are accustomed to the use of no tools but the most trivial digging and cutting implements, and they have the reluctance of all barbarous people to steady work. Nevertheless, Mr. Wiseman says, "cheap labor is practically available throughout the entire length of the railway." The only way that it can be had is to *force* the people to work. Perhaps England is ready to do that in the interest of "Christianity and civilization and the English Sabbath;" and we doubt not that it would be a capital thing for the Central Africans to be forced to work; but as Gordon would have said, "the scandal would be too great." The fact is that those who survey the line as well as those who build it will have to face not only the indolence, the ignorance and the poverty of barbaric people, but often their steady and bitter hostility. For instance, the Nile and its immediate neighborhood at the proposed crossing are controlled by the successors of the Mahdi, and a small force of Europeans going in there would be massacred. This condition would be found for 400 or 500 miles along the southern frontier of the Egyptian Soudan. What would be the temper of the people elsewhere we do not know. The Shillooks, who occupy the west bank of the Nile south of Fashoda, are naked savages, and Mr. Wiseman is correct in calling them "warlike;" in fact they have before now "cleaned out" more than one expedition of regular troops, and at least once killed the governor of Fashoda and a battalion or two with him.

For many hundreds of miles, probably for more than half of the route, there is no timber fit for cross ties. The acacias and other trees which are common enough rarely reach six inches in diameter. They make hard forests to work through, but are of no use for ties. Larger construction timber is almost entirely wanting. But for much of the route timber would not answer even if it were abundant, as the white ants would destroy it. Fuel for locomotives, other than wood, probably could not be found.

Finally, the whole zone is a region of mortal fevers. It is not so bad as the zone of greater rainfall near the equator, but it is worse than the drier regions to the north. There are individual white men who could live for years in this belt; but, speaking generally, of white men in mass, and of the country at large, a white man cannot live in it five years. One third of the men in an Egyptian battalion in Darfour died of disease in one year. They were in latitude 13°, where the general altitude of the country is about 2,000 ft., the soil light and the rainfall small. In the swamp regions of the White Nile and Bahr el Ghazal the fevers are far worse than in Darfour, Kordofan or Wadai. Between these extremes lies the line of the proposed railroad. What would be the fate of white men who undertook to build that road or to colonize along it, the reader can judge.

Space will not permit us to discuss a line up the Nile valley from Siout to Fashoda. It is enough now to say that from Wady Halfa south it would have to be preceded by an army of conquest and occupation. When Sir John Fowler, acting for the Khedive, caused surveys to be made for a railroad to Khartoum, and for another into Darfour, the construction parties could have had the loyal aid of those brave spearmen who killed Gordon and Burnaby and the two Stewarts, who annihilated Hicks' army, and who, at Abou Klea, came within an ace of wiping out a square of the stanchest infantry in the world. To-day those men would have to be fought—and it is England's fault.

We have said what we have said because we believe that it is a man's duty to correct evil and dangerous "Counsell," and not in any spirit of opposition to England's enterprises in Africa. Quite to the contrary, we believe that it is the duty and the policy, and will be the destiny of England, to open up the "dark continent." A proposition so broad and so old can be supported by many reasons and we will not take the space to restate them now; but we have no doubt that England's ascendancy in Africa will be for the good of the human race. There is no other people so fit to subdue and control a barbaric land as the English. A man of any race and country must see shining through the history of the extension of the British empire the noblest and most brilliant human qualities, the highest genius for war and for government, the deepest fortitude and the most patient and persistent common sense. So, we have nothing to say against England's occupation of Africa, but wish it God speed. Such an enterprise as this proposed Central African railroad can only hinder it. Africa is to be conquered, like any other continent, by patient advances on the easiest lines, and not by a *coup de main*.

The railroad from Mombassa toward the Victoria Nyanza is worth trying and is a proper step, but we have no notion that it will pay for a generation to come. So of the German road in from Bagamoyo. It would perhaps pay to start in from Lagos and build to the Niger; then, when trade develops, push on toward Bornu. It would not, however, be worth while to push a railroad up the Nile from Siout. The Nile itself and the existing railroad around the first cataract at Assouan are quite enough for the business to be done. Some day the road must be carried south from Wady Halfa, but that cannot be done now. Finally, when England gets ready to retake the Soudan, as she must do some time, the first step is to push a railroad across from the Red Sea to the Nile, say from Souakin, latitude 19, to Berber. By that route the heart of the Soudan would be within 250 miles by rail of deep water.

Had this railroad been built years ago, when an American engineer who had examined the country recommended it, the Mahdi's rebellion would have been crushed before it had fairly begun, a vast land would have been saved from untold suffering, and Gordon might still be doing his noble and beneficent work on earth.—*Railroad Gazette.*

EXPERIMENTAL RESEARCHES ON MECHANICAL FLIGHT.

THE following is a translation given in *Nature* of a communication made by Prof. S. P. Langley to the Paris Academy of Sciences on July 13:

I have been carrying out some researches intimately connected with the subject of mechanical flight, the results of which appear to me to be worthy of attention. They will be published shortly in detail in a memoir. Meanwhile I wish to state the principal conclusions arrived at.

In this memoir I do not pretend to develop an art of mechanical flight; but I demonstrate that, with motors having the same weights as those actually constructed, we possess at present the necessary force for sustaining, with very rapid motion, heavy bodies in the air; for example, inclined planes more than a thousand times denser than the medium in which they move.

Further, from the point of view of these experiments and also of the theory underlying them, it appears to be demonstrated that if, in an aerial movement, we have a plane of determined dimensions and weight, inclined at such angles and moving with such velocities that it is always exactly sustained in horizontal flight, the more the velocity is augmented, the greater is the force necessary to diminish the sustaining power. It follows that there will be increasing economy of force for each augmentation of velocity, up to a certain limit which the experiments have not yet determined. This assertion, which I make here with the brevity necessary in this *résumé*, calls for a more ample demonstration, and receives it in the memoir that I have mentioned.

The experiments which I have made during the last four years have been executed with an apparatus having revolving arms about 20 meters in diameter, put in movement by a 10 horse power steam engine. They are chiefly as follows:

(1.) To compare the movements of planes or systems of planes, the weights, surface, form, and variable arrangements, the whole being always in a horizontal position, but disposed in such a manner that it could fall freely.

(2.) To determine the work necessary to move such planes or systems of planes, when they are inclined, and possess velocities sufficient for them to be sustained by the reaction of the air in all the conditions of free horizontal flight.

(3.) To examine the motions of aerostats provided with their own motors, and various other analogous questions that I shall not mention here.

As a specific example of the first category of experiments which have been carried out, let us take a horizontal plane, loaded (by its own weight) with 464 grammes, having a length 0·914 meter, a width 0·102 meter, a thickness 2 mm., and a density about 1,900 times greater than that of the surrounding air, acted on in the direction of its length by a horizontal force, but able to fall freely.

The first line below gives the horizontal velocities in meters per second; the second, the time that the body took to fall in air from a constant height of 1·22 meters, the time of fall in a vacuum being 0·50 second.

Horizontal velocities ..	0m., 5m., 10m., 15m., 20m.
Time taken to fall from a constant height of 1·22 meters.	0·53s., 0·61s., 0·75s., 1·05s., 2·00s.

When the experiment is made under the best conditions it is striking, because, the plane having no inclination, there is no vertical component of apparent pressure to prolong the time of fall; and yet, although the specific gravity is in this more than 1,900 times that of the air, and although the body is quite free to fall, it descends very slowly, as if its weight were diminished a great number of times. What is more, the increase

in the time of fall is even greater than the acceleration of the lateral movement.

The same plane, under the same conditions, except that it was moved in the direction of its length, gave analogous but much more marked results; and some observations of the same kind have been made in numerous experiments with other planes, and under more varied conditions.

From that which precedes, the general conclusion may be deduced that the time of fall of a given body in air, whatever may be its weight, may be indefinitely prolonged by lateral motion, and this result indicates the account that ought to be taken of the inertia of air, in aerial locomotion, a property which, if it has not been neglected in this case, has certainly not received up to the present the attention that is due to it. By this (and also in consequence of that which follows) we have established the necessity of examining more attentively the practical possibility of an art very admissible in theory—that of causing heavy and conveniently disposed bodies to slide or, if I may say so, to travel in air.

In order to indicate by another specific example the nature of the data obtained in the second category of my experiments, I will cite the results found with the same plane, but carrying a weight of 500 grammes, that is 5,380 grammes per square meter, inclined at different angles, and moving in the direction of its length. It is entirely free to rise under the pressure of the air, as in the first example it was free to fall; but when it has left its support, the velocity is regulated in such a manner that it will always be subjected to a horizontal motion.

The first column of the following table gives the angle (a) with the horizon; the second the corresponding velocity (V) of *planement*—that is, the velocity which is exactly sufficient to sustain the plane in horizontal movement, when the reaction of the air causes it to rise from its support; the third column indicates in grammes the resistances to the movement forward for the corresponding velocities—a resistance that is shown by a dynamometer. These three columns only contain the data of the same experiment. The fourth column shows the product of the values indicated in the second and third—that is to say, the work T, in kilogrammeters per second, which has overcome the resistance. Finally, the fifth column, P, designates the weight in kilogrammes of a system of such planes that a 1 horse power engine ought to cause to advance horizontally with the velocity V, and at the angle of inclination a.

	V	R	$T=\frac{VR}{1000}$	$P=\frac{500\times 4554}{T\times 60\times 1000}$
45	11·2	500	5·6	6·8
30	10·6	275	2·9	13·0
15	11·2	128	1·4	26·5
10	12·4	88	1·1	34·8
5	15·2	45	0·7	55·5
2	20·0	20	0·4	95·0

As to the values given in the last column, it is necessary to add that my experiments demonstrate that, in rapid flight, one may suppose such planes to have very small interstices, without diminishing sensibly the power of support of any of them.

It is also necessary to remark that the considerable weights given here to the planes have only the object of facilitating the quantitative experiments. I have found that surfaces approximately plane, and weighing ten times less, are sufficiently strong to be employed in flight, such as has been actually obtained, so that in the last case more than 85 kilogrammes are disposable for motors and other accessories. As a matter of fact, complete motors weighing less than five kilogrammes per horse power have recently been constructed.

Although I have made use of planes for my quantitative experiments, I do not regard this form of surface as that which gives the best results. I think, therefore, that the weights I have given in the last column may be considered as less than those that could be transported with the corresponding velocities, if in free flight one is able to guide the movement in such a manner as to assure horizontal locomotion—an essential condition to the economical employment of the power at our disposal.

The execution of these conditions, as of those that impose the practical necessity of ascending and descending with safety, belongs more to the art of which I have spoken than to my subject.

The points that I have endeavored to demonstrate in the memoir in question are:

(1.) That the force requisite to sustain inclined planes in horizontal aerial locomotion diminishes, instead of increasing, when the velocity is augmented; and that up to very high velocities—a proposition the complete experimental demonstration of which will be given in my memoir; but I hope that its apparent improbability will be diminished by the examination of the preceding examples.

(2.) That the work necessary to sustain in high velocity the weights of an apparatus composed of planes and a motor may be produced by motors so light as those that have actually been constructed, provided that care is taken to conveniently direct the apparatus in free flight; with other conclusions of an analogous character.

I hope soon to have the honor of submitting a more complete account of the experiments to the Academy.

A NOVEL EAST INDIAN WELL.

THE method of well construction illustrated herewith is the invention of Rai Bahadoor Ganga Ram, a civil engineer, executive engineer of the public works department at Lahore, Punjab, India, and is known as "Ganga Ram's patent well." It is described in Indian engineering as a "cheap and efficient method of making irrigation and other wells in India," and consists in radiating or interlocking bricks of a special shape and design which when laid only one brick thick, dry or in mud or lime, effectually serve all the purposes of an ordinary well steining in every respect, the shape being so designed that each brick interlocks with or is keyed into the adjoining bricks on each side and those above and below, so that the necessity of any tie rods and of more than a single thickness of bricks is obviated and the sinking of wells facilitated.

The invention provides either (1) that each brick shall be so moulded as to have both a mortise and tenon in dovetail shape, so as to grip the bricks on either side and above and below, the mortise and tenon being so arranged as to break joint throughout, or (2) that a separate key or tenon should be made to fit into mortises in the three surrounding bricks dovetailing into them, so as to interlock them.

The novelty of this invention lies in the following particulars:

First—That the bricks are so shaped that they interlock each other vertically as well as transversely, thus dispensing with the necessity of a cementing material or tie rods.

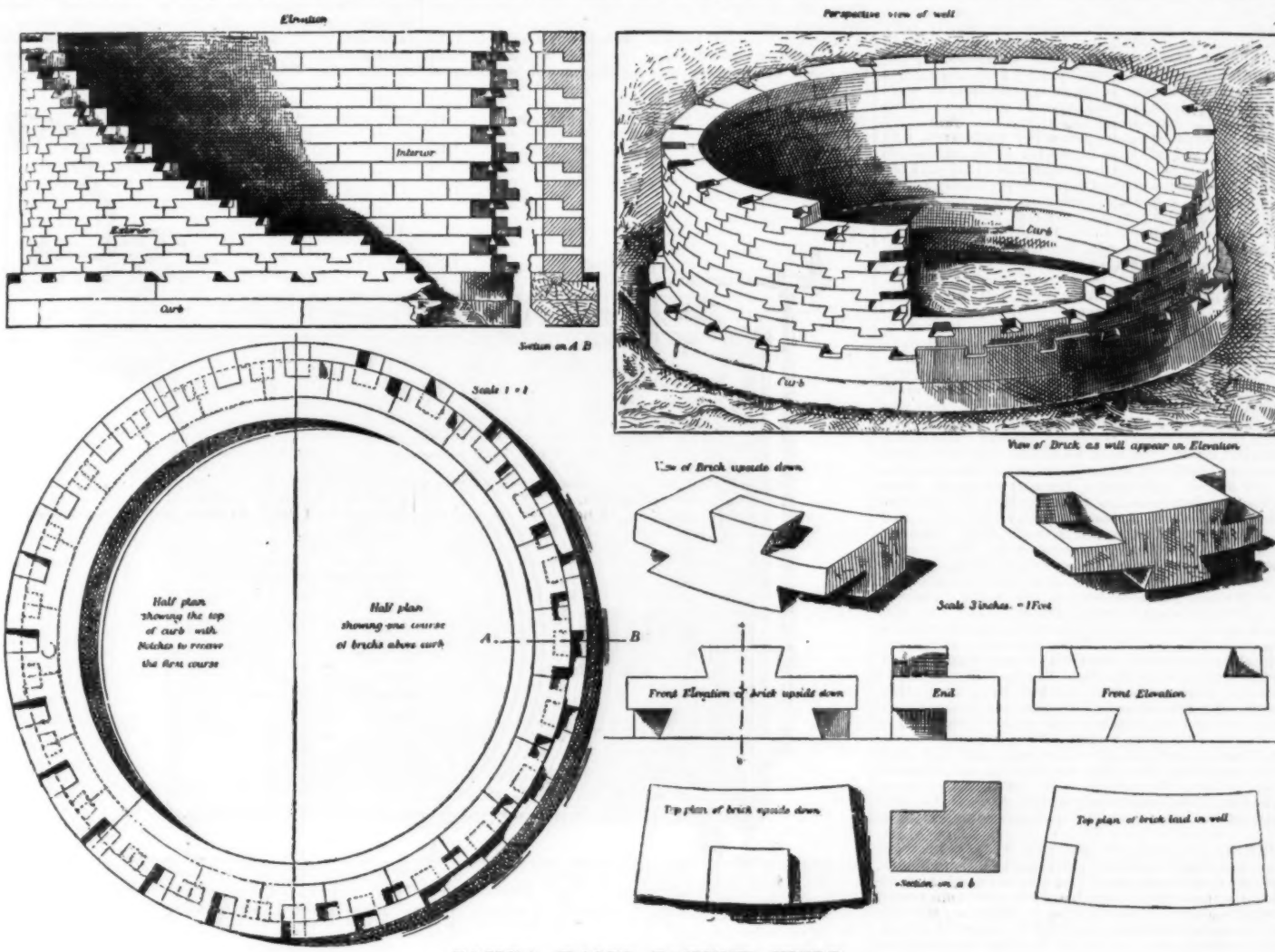
Second—That owing to this particular shape of bricks the thickness of steining can be safely reduced to the width of one brick only, thus effecting an immense saving in cost.

Third—That there are sufficient interstices left in the steining to admit of side infiltration, without the slightest danger to the brickwork.

Fourth—That the danger of in-blow of sand is reduced to minimum.

Fifth—That no skilled masons are required for building, an intelligent coolie being able to put the bricks together, these, owing to their peculiar shape, fitting into each other.

Upon the whole there is claimed for this method of well construction greater simplicity than in the ordinary plan of sinking wells, while it is asserted that a saving of one-third is effected in the cost. The illustrations explain themselves.


Elevation
Interior
Exterior
Curb
Section on A B
Scale 1 = 1
Half plan showing the top of curb with Notches to receive the first course
Half plan showing one course of bricks above curb
A
B
Perspective view of well
Curb
Curb
View of Brick as will appear in Elevation
View of Brick upside down
Scale 3 inches. = 1 Foot
Front Elevation of brick upside down
End
Front Elevation
Top plan of brick upside down
Section on a b
Top plan of brick laid in well

GANGA RAM'S PATENT WELL.

PERSIAN CARPET WEAVING.*

CARPETS are manufactured in many parts of Persia; Isfahan, Shiraz, and Kerman have all a certain fame for carpets; and, similarly, Kermanshah, Yezd, Kashan, and Shushter are known for their cotton *khelims*. The most important manufacture of carpets, however, is in northwest Persia, in sundry provinces, with Sultanabad in Irak as the principal center.

Sultanabad is a comparatively new town, having been built, perhaps, sixty to eighty years ago. In the numerous villages by which it is surrounded, carpet weaving has been the great branch of industry for generations past, although in late years considerable improvements have been made in the class of work produced.

Of the valuable ancient carpets, relatively few are found nowadays; like curios, the country is pretty well exhausted of them. Persia has been visited by so many European travelers in recent years, that its formerly hidden treasures in the shape of curiosities, etc., have been hunted up out of their corners, and have found their way to European museums or private collections.

It may seem almost incredible to many people that among the ancient carpets, whose manufacture dates back for such a considerable number of years, there are so many to be found that are still in good condition and comparatively little worn. The secret of this is that not only has great care been bestowed on the weaving of the carpets and on the quality of wool used, but because of the custom prevailing in the houses of Eastern people. While we, with our more civilized ideas, enter our own and other people's rooms with the same boots with

* This report, prepared by M. G. de Vries, is communicated to the Society by Mr. George Curzon.

which we walk through the muddy streets, a Persian never enters any room, either his own or his neighbors', without leaving his boots or shoes at the door. The Persian carpets of modern times are now so well known in Europe that a more detailed description as to the way in which they are manufactured may prove interesting.

The weaving is done exclusively by women of all ages. The only share the men take in the work is that to them the merchants give out the designs (*wagirehs*), the colors, and money required for the weaving. The men also see to the purchase of the wool, etc., and afterward deliver the carpets to the merchants, getting all the blame for mistakes made in the weaving by their respective wives and daughters. A loom itself is a very inexpensive and simple structure, consisting of four wooden poles, which generally occupy the whole length of the weaving room. The first thing a weaver has to do when he starts weaving is to buy the necessary material for mounting his carpet and for the warp, the mounting being also a duty allotted to the men. Then he buys his wool and sends it to the dyer, to have it dyed according to the samples given out to him by the merchant. It must not be thought, however, that a weaver as soon as he has obtained an order for a carpet hurries home to his village to start it the next morning. There certainly are quick weavers, but they are few and far between. A great many, as soon as they have received the cash advanced to them, spend a greater or smaller part of it on themselves. They buy themselves clothing, pay off debts, gamble, or invest in land, gardens, grain, etc. By the time the carpet ought to be ready the weaver frequently only begins to think of starting it. His speculations often turn out badly, and he finds himself consequently unable to finish the carpet contracted for with the money he has left. However, he buys a little wool to start with and has it dyed, a quantity sufficient perhaps for one-third of the carpet he has to weave. When this is finished, his resources are probably exhausted, and he is therefore obliged to look out for other means to complete the carpet. His next move is to try and obtain an order for a second carpet from another merchant, of course solemnly declaring that he has no contract for a carpet for anybody else, and promising to deliver it within the stipulated time. He is always, according to his own words, the very best and quickest weaver of his village, and has plenty of reasons to show for happening to be without work just then. Most frequently his excuse for having left his former master is that owing to a serious (but generally imaginary) illness of his wife, his last carpet was one month overdue, for which interest had been deducted, and he therefore does not wish to serve that master any more. His village being perhaps 20 to 30 miles away, the truth of such statements cannot be determined at once.

Instead of applying to a second master, he also frequently goes to the one for whom he is weaving, and tells him that his carpet is almost finished, that it will be delivered during the next week, etc., but that, as he wants some money for himself, he would be glad of a small advance on account of his next contract! Supplied with fresh money, he then finishes the original carpet. First, however, he must buy the remainder of the wool required and send it to the dyer. The latter is, in most cases, quite as careless as the weaver, and never dyes the same shade of color twice, the hue being either darker or lighter. The result is that the wool with which the first part of the carpet is woven is of a different shade from the second part; but this can no more be helped, and the carpet is delivered as it turns out, viz., spoiled! This, however, is not the only consequence of the weaver's private speculations. He has to make up for his loss somehow or other, and accordingly buys an inferior kind of wool than that contracted for, gets other and cheaper colors dyed than his samples, and employs less experienced weavers, so as to save something in wages. With his next carpet he deals very much in the same way, and the only means of punishing him is to dismiss him, and to make him pay for the difference in value between the carpet delivered and the carpet contracted for. If he does the latter, he has of course to cheat somebody else first.

Even if we take the case of a good weaver, his work seldom progresses without incessant interruptions. Often the dyer disappoints him by keeping him waiting for his wool; but more frequently his own household affairs put a temporary stop to weaving. His wife has to attend to her baby, milk the cows, make butter, see to the sheep, etc., all of which cause constant delays in the progress of the work.

When weaving is going on regularly, three to four women work at a carpet of fairly large size, the weaver's wife being, as a rule, the principal weaver, and at the same time superintending the work of her daughters or hired women. The rule is that at each end of the board on which the women are seated there should be one female overseer. For carpets of very large size, in the weaving of which seven or eight women are employed, there is also one overseer in the middle. At the age of seven years girls begin already to assist in the weaving; previous to that age, they spend a year or so on the board, watching the other women, so that at an early age they may be accustomed to the work. If a young woman who has been brought up to the loom gets married, the first thing she does is to try and obtain an order for a carpet, so that the weaving of carpets passes down from one generation to another.

People in Europe who buy Persian carpets little think of the enormous labor that has been expended on the weaving. It is done exclusively by hand; and every stitch in the carpet is made separately, being afterward clipped with the scissors and beaten down. Some idea of the work may be formed, when it is known that in a good carpet there are about 10,000 stitches to every square foot.

The clipping and beating down are also very essential points in the work. The clipping, for instance, must be done every time with equal care, otherwise, when the carpet is finished, the pile will be short in some places and longer in others. Upon the beating down depends the closeness of the texture. The more a weaver beats her stitches down, the finer, of course, the carpet is. She knows how many stitches she has to weave to every quarter of a Persian yard; but she generally makes less, so as to save wool, time, and trouble. There are carpets, like the cheap Heratis, which have no more than 50 stitches, and 75 stitches at the highest, to every quarter Persian *zar*. Good quality carpets have 85 to 95 stitches, and finely woven rugs have frequently over 200 stitches. At the latter rate, there would be fully 40,000 stitches to a square foot.

In summer time, when the days are long, the work goes on fairly fast; but in winter it progresses very slowly. When the cold is not too intense, the women have a pot with fire between them when weaving, over which they warm their fingers from time to time, but, on very cold days, they suspend work altogether.

The width of a carpet depends upon the size of the loom, but the length can be made of any dimension. When the weaving has all but reached to the top of the loom, the carpet has to be taken down and rolled up at the bottom, and the work is then started again upward. The rolled up (finished) part is sewn to the bottom part of the loom, and if this is not done very carefully, the remaining portion of the carpet is sure to "go out"—in other words, the carpet turns out crooked.

There are several European firms engaged in the trade, whose headquarters are in Manchester and in London. Besides these European houses, a great number of Persian and Turkish merchants export carpets.

When the trade was exclusively in the hands of native merchants, no other carpets were woven than the ordinary Herati and Shah-Abbas kinds. By introducing new designs, great improvements have been made in this direction by the European firms. These designs, which have been made at great expense and have cost much labor, are their individual property. Weavers have now grown pretty well accustomed to weaving these new designs, but they frequently spoil the effect of them by leaving out part of the original design, and placing something of their own invention in its stead. Even nowadays nearly all the carpets exported by Persians and Turks are Heratis and Shah-Abbas patterns, with a few very simple designs among them. They do not understand the art of designing something novel, but are very clever in the art of pirating the designs belonging to the European firms. Formerly there did not exist any law against this pirating of designs, but as in recent years this evil grew worse and worse, the Persian government, through the influence of the British Legation at Teheran, have at last, at the commencement of this year, acknowledged the right of property of designs, and the copying of them is now strictly prohibited.

In addition to designs, the shades of colors employed in the carpets are a matter of vital importance, requiring the most careful attention, since they must be in harmony with the ever changing taste of European markets. At present, entirely new colors are the rage, which give a carpet more the appearance of an antique than of a new one; but it is certain that the taste for these fancy colors is only a passing one, and the sooner people return to the former colors, the better. Aniline is still greatly used in the dyes by the native merchants, but carpets woven of such colors should be entirely avoided, as the colors fade away after a time.

Besides woolen carpets, rugs are exported, woven entirely of silk. The weaving of such rugs is done in the same way as the weaving of carpets, but the labor is far greater in proportion, as they are always of a very fine make. Such rugs can be used as table and sofa covers, *portieres*, etc., but, as they are made of pure silk, they are very costly.

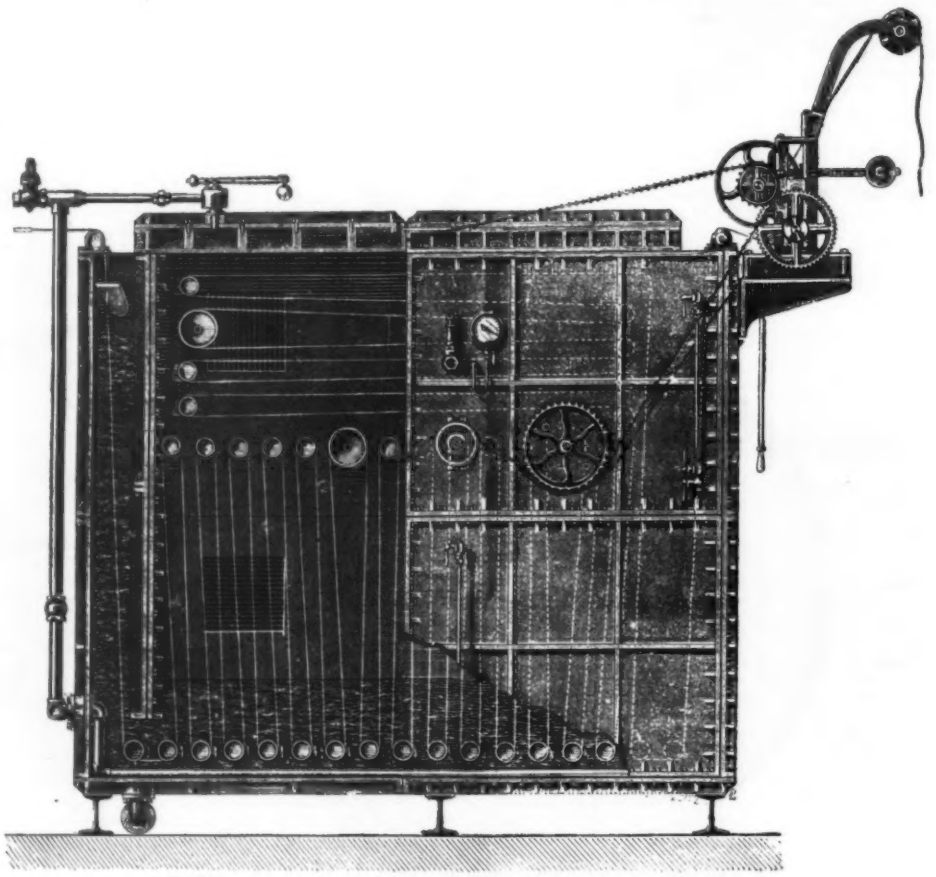
Altogether, it will be seen from the foregoing that the Persian carpet business is far from being a bed of roses. From all points of view the trade is a most difficult one; and long experience, and a thorough acquaintance with the weavers and their ways, are necessary to surmount some of the numerous obstacles.

The districts where carpets are woven are Ferahan, Muscabad, Japelag, Kezaz, Cherreh, and Saraband, comprising in all about 150 villages, with a total number of looms estimated at about 5,000. The quality of carpets which these looms produce varies according to the districts. Most of the above districts produce only second and third quality work. In two of the largest, however, a fair proportion of the looms produce first quality carpets.

In some of the looms as many as five to six hands are employed, but this is rather an exception. The average is three weavers to a loom of fairly large size, one and two weavers for small looms; so that, if all looms are engaged, close upon 1,000 hands would be employed. A fast and steady weaver could deliver annually three to four carpets of ordinary size; but a large number only weave at intervals, and slow weavers take sometimes eighteen months to two years to finish one carpet. The irregular weaving makes it, therefore, impossible to give anything like a reliable estimate of the annual output or export value.—*Jour. Soc. of Arts.*

BUCKING KEIR FOR COTTON FABRICS.

Previous to dyeing or printing, cotton fabrics have to undergo a bleaching or scouring in order to free them from all the greasy substances that they may have become charged with during the process of weaving. This operation usually comprises alternate treatments with an alkaline solution and steam. In order to avoid the great loss of time and manual labor necessitated by the putting in and removal of the fabrics, Mr. Edmaston, of Salford, has devised an



BUCKING KEIR FOR COTTON FABRICS.

apparatus which we borrow an illustration and description of from *Industries*. The apparatus consists of a large, rectangular metallic chest having a partition arranged at each extremity and forming communicating chambers. The solution of soda is furnished by a special reservoir mounted in the two extreme chambers at a level capable of forming an equilibrium to the pressure of the steam that is introduced into the central chamber. This steam is led by a vertical pipe which is afterward bent at its entrance into the apparatus in order to heat the solution of soda, and turns up vertically in order to supply the central chamber. The fabric to be treated is stretched over rollers so arranged that it is immersed alternately in the soda and steam baths, and then undergoes a prolonged contact with steam in the upper part of the apparatus, and finally makes its exit through one of the end chambers, just as it entered through the other, that is to say, in dipping into the alkaline solution. On making its exit from the apparatus, the fabric passes between two drying rollers, and is then carried along by reels to the storage boxes in order to await dyeing or printing.

It will be seen that the system realizes that alternation of treatment by soda and steam that is recognized as necessary for scouring, but it presents, in addition, great advantages over hand processes. In the first place, the fabrics, moving in the form of an endless cloth, are much more sensitive to the reagents than when they are in a pile. The work is thus much more regular, more rapid, and much more economical as regards the consumption of steam. On another hand, the manual labor is reduced in a large proportion, not only in the treatment itself, but in the folding in the storage cases, which can be effected automatically by means of an alternating motion given to the delivery rollers after the exit of the fabric from the apparatus. It therefore presents serious advantages

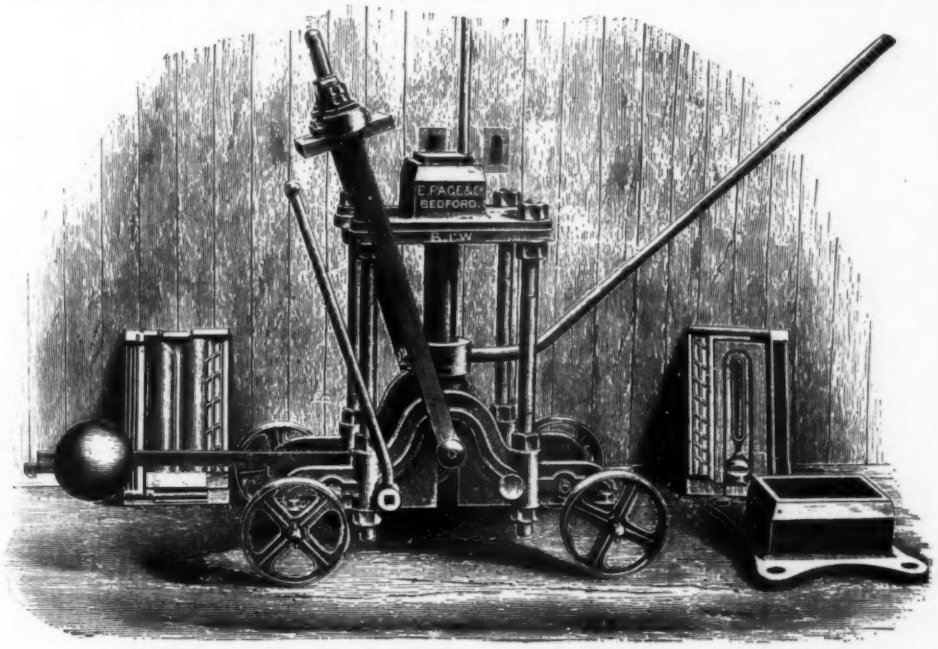
over the hand treatment of cotton fabrics in the process of scouring, and, in certain works, where, so as not to multiply boilers, the process of alkaline treatment during the day and the boiling during the night had been carried on, it has been found possible to proceed with the whole operation during the day only, by reason of the saving in steam obtained.—*Le Genie Civil.*

IMPROVED BRICK PRESS.

THE brick press here illustrated was exhibited at the Doncaster Royal Show by Messrs. E. Page & Co., Bedford. The press is of new design, and will press plain or ornamental bricks or paving squares, plain or ornamental roofing tiles of any dimensions up to 14 inches square, or French tiles up to 16½ inches long by 14 inches wide. The table of the press can be raised or lowered to any required position on the four upright columns, and the top plate or cover is capable of adjustment on the two side rods in a similar manner, so that bricks or tiles can be pressed to any desired thickness. Boxes of various sizes are easily attached to the press.—*Iron.*

THE MARINER'S COMPASS.

A WRITER in the North China *Herald*, of Shanghai, devotes a learned article to detailing and discussing the facts regarding the claim of the Chinese to have invented the mariner's compass. They did not learn the properties of the magnetized needle from any other country. They found it out for themselves, though it is impossible to point to the man by name who first observed that a magnetized needle points north and south. He suggests that it came about in this way. The Chinese have in their country boundless tracts of ironstone, and among these no small portion is magnetic. Every woman needs a needle, and iron early took the place of the old stone needles, and were commonly used before the time of Ch'in Shih-huang—that is, more than twenty-one centuries ago. Whenever a needle happened to be made of magnetic iron, it might reveal its quality by falling into a cup of water, when it happened to be attached to a splinter of



IMPROVED BRICK PRESS.

wood, for example. It came in some such way to be known commonly that certain needles had this quality. The great producing center for magnetic iron is T'szchou, in southern Chihli This city was very early called the City of Mercy, and the magnetic stone produced there came to be known as the stone of T'szchou, and so *t'szshih* became the ordinary name for a magnet. Later, the Chinese began to speak of the city as the "City of the Magnet," instead of calling it the "City of Mercy."

The polarity of the magnetic needle would become known to the Chinese of that city and its neighborhood first. The first who noticed the polarity would be some intelligent person, who communicated the fact as an unaccountable peculiarity in an age when omens and portents were diligently sought for in every natural object and phenomenon.

The earliest author who mentions the "south-pointing needle" lived in the fourth century B. C. There can be no reasonable doubt that the polarity of the needle was known at that time. The discovery of the fact must have preceded the invention of any myth embracing it. As to the discovery, there is no reason to suppose it was in any way foreign, because the Chinese use an enormous number of needles, and have an inexhaustible supply of ironstone. But, though the polarity was known, it was not turned to a practical use till the Tsin dynasty, when landscapes began to be studied by the professors of *fengshui* or geomancy. There was at that time a general belief in the magical powers of natural objects. This was a Buddhist doctrine, and it took firm hold on the Chinese mind of that age. The Chinese philosophers of those times taught that indications of good and ill luck are to be seen all through nature. The polarity of the needle would take its place in this category of thought. Though it is not distinctly mentioned by writers of the fourth century, yet to their disciples it became an essential part of the landscape compass which the professors of *fengshui* all use. Kwo Pu, the founder of this system, died A. D. 324, and it was not till four centuries later that the *fengshui* compass began to assume its present form. The compass used by the professors of geomancy for marking landscape indications was first made about the eighth century. It was of hard wood about a foot wide, and it had in the center a small well, in which a magnetized needle floated on water. On the compass were inscribed several concentric circles, as on the wooden horizon of our globes. They embrace the twelve double hours, the ten denary symbols, eight diagrams, and other marks. This compass was used in preparing a geomantic report of any spot where a house or tomb was to be constructed, so that the construction might not be upon an unlucky site or planned in an unlucky manner. At the same time there was living a Chinese who had studied Hindoo astronomy, and was the imperial astronomer, and also a Buddhist priest. He noticed that the needle did not point exactly north, and that there was a variation of 2° 95'. This variation went on increasing till a century later—that is, till the ninth century. A professor of geomancy then added a new circle to the compass. On this improved compass the first of the twelve hours begins on the new circle at 7½° east of north.

The compass, it will be observed, grew out of the old astrological report or nativity paper, calculated from the position of the stars, and prepared in the Han dynasty by astrologers as a regular part of social life, especially when marriages were about to be solemnized. Some of the old astronomical circles are preserved in the new geomantic chart. This was the compass used when Shen-kwa wrote on the south-pointing needle in the eleventh century. This author mentions that any iron needle acquires polarity by rubbing it on a piece of loadstone. He alludes to the variation as a fact which he himself had observed, and speaks of the south-pointing needle as an implement used by the professors of geomancy. By them it was employed in the form of a float upon water. After this, in 1122, an ambassador to Corea describes the use of the floating needle on board ship while he made the voyage. This is the first instance, the earliest by more than a century, of the use of the mariner's compass on board ship, found as yet in any book, native or foreign. The existence of the book in which this is recorded settles the question of the first use of the mariner's compass at sea in favor of the Chinese. At that time the needle floated on water supported on a piece of wood, but in the Ming dynasty some Japanese junks engaged in piracy were captured by the Chinese, and the compass in use on board was found to have the needle dry and raised on a pivot, while still pointing southward. The Japanese had learned from the Portuguese navigators to make a compass of this kind, and probably the needles they used were brought from Europe. From this time, the Chinese adopted the principle of a pivot, and made their compasses without a well of water in the middle to float the needle in. Charts were probably used of a very rough kind, but how far is not known. What is known is that the junk master was aware of the direction in which the needle must point to reach the port to which he was going. In the Sung dynasty, embracing part of the tenth, as well as the eleventh, twelfth, and part of the thirteenth centuries, Chinese junks went to Persia and India. The Arabs trading to China directly would learn at that time the use of the compass, and would apply it on board their dhows. From them the Europeans learned this useful invention.

The credit of the discovery, both of the polarity of a magnetized needle and its suitability for use by mariners at sea, must, therefore, according to this writer, be given to the Chinese. It was China also that has the credit of having first noticed that any iron needle may be polarized by rubbing it with a magnet. In the thirteenth century the Arabs used a floating compass on their dhows. The needle was made to float on the water by attaching it crosswise to a cornstick or splinter of wood. A magnet applied to it drew it into a north and south direction. They would use western notation to mark the quarters and intermediate points on the horizon. When, therefore, the mariner's compass was adopted from them, the Chinese 24 points were not communicated. In the European compass the notation of 32 points is western, and rests on the winds and the sun. In the Chinese primitive mariner's compass the notation is that of the professors of geomancy, and rests on the old astrological division of the horizon into twelve double hours. From the Arab account we learn, what the Chinese accounts do not tell us, that the Chinese floated the needle by inserting it in a splinter of wood.

PARAMIDOPHENOL.

IN a communication to the Societe Francaise de Photographie on May 1 last, MM. Auguste and Louis Lumiere called attention to the fact that Dr. Andresen, who first used eikonogen as a developer, had also made experiments with the phenylene-diamenes and amidophenols. With the phenylene-diamenes he evidently met with some success, and they are included in his patent of April, 1888; but the amidophenols are not mentioned, and it seems probable that with these he met with no favorable results. Without knowledge of Andresen's experiments, the Messrs. Lumiere, considering the chemical structure of the amidophenols and noting their close relationship to the phenylene-diamenes, and also to the amidobetanaphthol compound, eikonogen, were led to experiment with them as developing agents. As a result of their work they recommend the paramidophenol with sodium sulphite and carbonate as a new and advanced developing agent.

Paramidophenol is derived from phenol, or, as it is commonly called, carbolic acid, one of the products of the distillation of coal tar. The first step in its preparation is the production of paranitrophenol. This is made by gradually adding one part of carbolic acid to a cooled mixture of two parts of nitric acid having the specific gravity of 1·34 and four parts of water. An oil separates which is washed with water by agitation and then distilled with steam. The paranitrophenol remains in the distillation apparatus, and is extracted by boiling with water. On pouring off the water while hot and allowing the solution to cool, the paranitrophenol will crystallize in long colorless needles that melt at 114 degrees C. and turn red on exposure to the air. From the nitro compound the amidophenol is produced by the action of metallic tin and hydrochloric acid. It crystallizes in thin colorless plates that melt at 184 degrees C. In water it dissolves in the proportion of 1 in 90 and in alcohol 1 in 22 parts. The chemical structure of the paramidophenol is C_6H_3 (OH) (NH_2), and the result of its oxidation in alkaline solution is the production of quinone (not quinol) or quinoimide. The water solution turns violet red on exposure to the air, especially in the presence of alkalies, but the addition of sodium sulphite prevents this discoloration.

The Messrs. Lumiere give the following formulas for the development of gelatino-bromide of silver dry plates:

Water	1,000
Sulphite of soda	200
Carbonate of soda	100
Paramidophenol	12

Or still better—

Water	1,000
Sulphite of soda	200
Carbonate of lithia	12
Paramidophenol	12

The first formula gives a very energetic developer, and is especially convenient in the development of instantaneous photographs.

The paramidophenol, which acts as a developer, presents the inconvenience of not being very soluble, so that it is not possible to modify the developer as in the case of pyrogallic acid.

Hydroquinone and eikonogen have, however, this same inconvenience in an equally high degree, and the paramidophenol has the advantage over these latter, especially the hydroquinone, of never discoloring the gelatine.

The solution will last a very long time, even in open-mouthed bottles, and negatives developed with old solution never present that yellow tint that is frequently to be remarked when other developers are used.

The deterioration of the developer is very slow, so much so that in 100 grammes of solution six or seven plates 13 × 18 cm. can be developed without there being the least appreciable difference between the first and the last.

Paramidophenol is expensive, but principally because there are not at present many uses for it, and also because the processes for purifying this agent have not been studied. The substance which is met with commercially under the name of paramidophenol is often very impure; but there is no doubt that on the attention of chemists being directed to its photographic value this substance will be more easily produced in a state of purity, while, at the same time, its cost will be diminished.

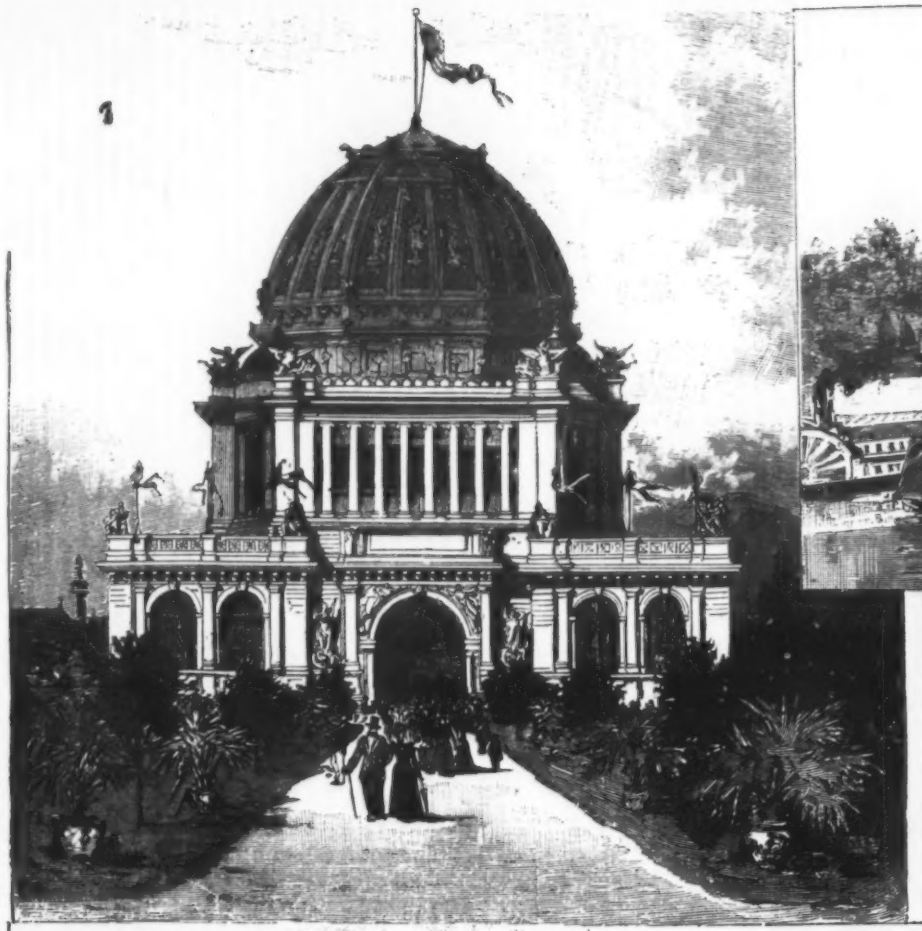
Mons. Leon Vidal, the editor of *Le Moniteur de la Photographie*, in Paris, says of this new developing agent: "We have been able to test this developer, from which we have obtained the best results, as well from the point of view of energy as from that of rapidity and durability."—*Bulletin.*

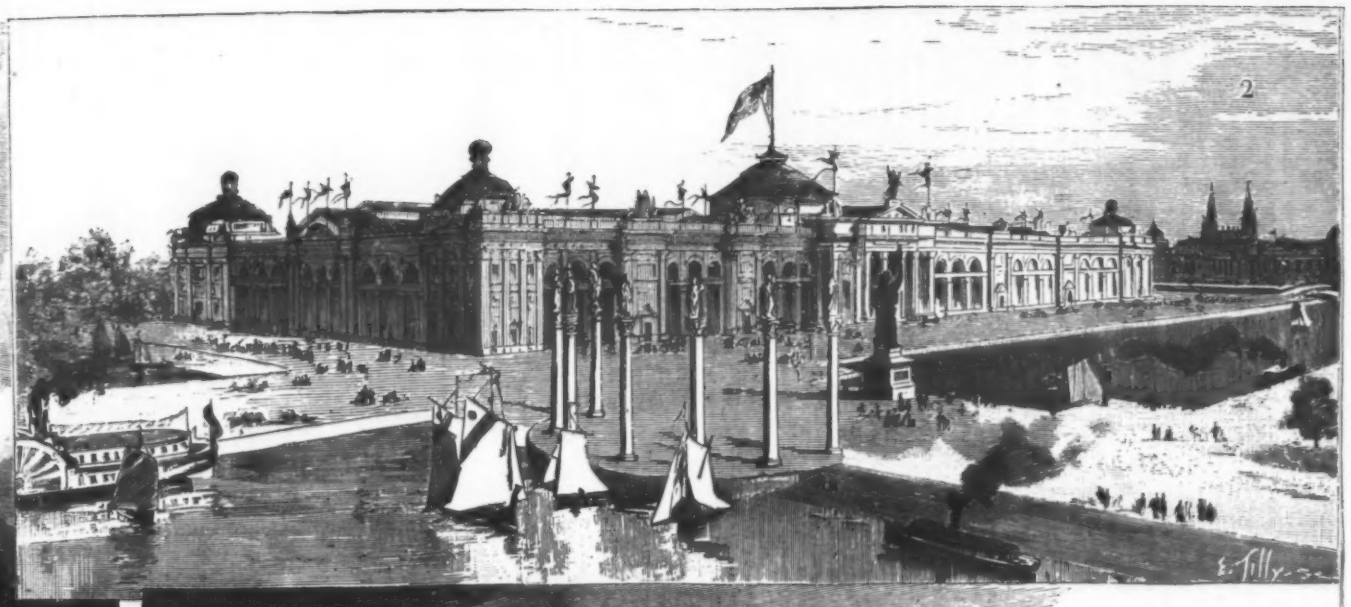
THE SPONTANEOUS IGNITION OF CARBON BISULPHIDE.

By Dr. MAX POPEL.

IN view of the widespread application of carbon bisulphide in extraction processes, and of the frequent explosions and fires which are caused by its spontaneous ignition—*i. e.*, without its actually coming in contact with flame or any red hot substance—it is of interest to collect and publish all the observations which have been made concerning the causes of such accidents.

Unfortunately, the nature of carbon bisulphide is by no means thoroughly known; in particular, we have no complete data as to its behavior at different temperatures and pressures, mixed with other gases, air, etc., in contact with metals and other substances; and yet a knowledge of these very points is necessary before the substance can be employed with safety. The main difficulty to be met with in the employment of carbon bisulphide is its volatility. Even at a very low pressure (0·1 atmosphere and less) it is quite impossible in an extraction apparatus to prevent its escape by means of taps, etc. Again, the air which is always admitted on filling the apparatus is again drawn out, saturated with the vapor, the loss increasing with the temperature. In the course of some experiments instituted to ascertain the actual amount of material carried away by the air, a spontaneous ignition of carbon bisulphide was observed under the





1. Pavilion of the Administration. 2. Pavilion of Agriculture. 3. Pavilion of Electricity. 4. Palace of Machinery.

THE WORLD'S COLUMBIAN EXPOSITION, CHICAGO, 1893.

following circumstances: The tube which connected the interior of the apparatus with the air, and which had previously ended near the roof of the building, was bent over and the end allowed to dip about 10 cms. into a vessel filled with oil. It was found that the oil absorbed the carbon bisulphide almost completely, and that the whole loss, at the temperature of the cooling surface (10–12° C.), was only very small; but that it amounted to several liters in the course of a very few hours at a temperature of 8–10° above this. A pressure of about one-eighth of an atmosphere was also set up in the apparatus, owing to the descending path which the air had to take and to the pressure of the oil, and this, of course, affected the boiling of the carbon sulphide. In order to remedy this, the apparatus was to be removed and replaced by another arrangement. While a workman on the roof was screwing off the descending arm of the pipe, I was standing by the oil flask, which was perfectly cold, as was also the pipe dipping into it. In order to allow a little more room for the motion of the pipe, I placed the flask at a lower level, and, just at that moment, the workman informed me that the pipe was beginning to get very hot at the joint. I was about to quit the place and see for myself if this were correct, when an explosion took place in the apparatus, and the oil saturated with carbon bisulphide took fire. In this case, therefore, the spot at which the ignition started can be determined with a certainty which is rare in accidents of the kind. No external influences were possible, and the idea that the explosion was caused by the absorption of oxygen by the oil and consequent heating is disproved by the fact that the whole remained quite cool until the actual moment of ignition. The only possible explanation is that the mixture of carbon bisulphide and air was raised to its igniting point by the heat developed in the pipe by the friction at the bend which was being unscrewed. The pressure being diminished by the lowering of the vessel, the flame spread downward and ignited the oil. The actual temperature attained in this case could not be ascertained, but the following experiment shows that a mixture of carbon bisulphide and air will ignite even below the boiling point of water. A watch glass containing carbon bisulphide was placed in a new copper oven with smooth walls; explosion took place regularly at 96–98°; when the walls were covered with a layer of clay, this no longer occurred, so that the copper seems to have played an important part in the phenomenon. Mixtures of carbon bisulphide and air readily ignite when brought into contact with iron pipes, through which steam at 3–4 atmos. (135–145° C.) is passing. The less carbon bisulphide there is in the mixture, the higher is its ignition point and the sharper the explosion.

It is, therefore, necessary in places where this substance is employed to cover all steam pipes, cocks, and valves with great care, and also to work without any pressure, so as to avoid loss. Unfortunately it is impossible to employ the vacuum, since the escape of the vapor into the pump cannot be avoided, and explosions would be caused by compressing it when mixed with air. If it is convenient to keep the condensing water at a low temperature, the loss from evaporation is only small, but in any case too much condensing surface cannot be employed. Finally, the workman intrusted with the care of this apparatus must be intelligent and reliable.—*Chem. Zeit.*

THE WORLD'S FAIR, CHICAGO, 1893.

ALTHOUGH there will be four days of celebration at Chicago, in Oct., 1892, with fireworks, parades of troops, etc., and an official dedication of the Columbian World's Fair, the exhibition itself will not be opened till the 1st of May, 1893. Our illustration gives a good idea of some of the principal buildings, according to the now completed plans of the architects and builders, work on them being already under way and being vigorously pressed.

The Administration Building is said to be, architecturally, the gem of the group. It will be at the west end of a great court in the southern part of the site, and will have a gilded dome 120 feet in diameter and 220 feet high. The building will cover an area of 250 feet square, and will have a central rotunda 175 feet square, surrounded on all sides by an open colonnade of noble proportions. Each of the four corner pavilions of the building, four stories in height, will be divided into offices for the various departments of the administration, and lobbies and toilet rooms.

The main machinery building will be 850 by 500 feet. It is just south of the Administration Building, and is spanned by three arched trusses, so that its interior will have the appearance of three railroad train houses side by side, surrounded on all the four exterior sides by a fifty foot gallery. The trusses are to be built separately, so that they can be taken down after the Fair and sold for use for railway purposes. In each of the long naves will be an elevated traveling crane running from end to end, for moving heavy machinery.

The machinery building, and the structures for agriculture, electricity, the liberal arts, fisheries, and the government displays, will be on a level of five and a half feet above the lake.

THE COLUMBIAN WORLD'S FAIR.

IN starting out to give a brief statement of the present condition of this enterprise, we wish to record once for all our protest against its name. Of course it will do no good to protest, but one may at least have the satisfaction of speaking his mind. Why under the sun should it have been called an exposition instead of exhibition, or just a plain fair? In old times the simple and short English word fair was good enough. This was gradually crowded out by exhibition, and in recent years the French word exposition has been adopted. The only reason for it is that somebody has thought the word more elegant, just as people west of a certian longitude say gotten when they mean got. With this preliminary growl in the interest of the vernacular we shall cease to make any protest against the scope or management or conduct of the enterprise until there is a better reason for criticism than is now apparent.

After very tedious and discouraging delays the affairs of the exposition seem to be on such a footing that we may expect them to go on to successful completion. The site finally decided on as best suited to the needs of the fair, Jackson Park, lies in the south part of the city along the lake front, and is the east portion of the South Park system, and the Midway Plaisance, about 600 ft. wide, connecting Jackson and Washington Parks, the latter lying about a mile to the west. Contract work, the aggregate of which is considerably more than $3,500,000, is now in progress at Jackson Park. The construction of the buildings is fairly under way. The time within which the structures must be completed is short for work of such magnitude, but this is fully realized by the Construction Department, and accordingly precautions which, it is believed, cannot fail are being taken to insure the readiness of everything for the ceremonies of dedication on Oct. 12, 1892.

Contracts have already been let for eight of the buildings. These buildings, their architects and contractors, are as follows:

Mines and Mining.—S. S. Beman, architect, Chicago.

Carpentry work, Barnett Rickford & Chapman	$99,500
Ironwork, King Iron Bridge and Manufacturing Co.	57,525
Exterior covering, Phillipson Decorative Co.	34,800
Roof and skylight	21,656
Other items	12,635
Total	$229,116

The style of the Mines Building is classic, and its dimensions 700 by 350 ft., with the height of the main cornice 65 ft. There is a pavilion at each of the four corners 85 ft. square and 90 ft. in height, surmounted by a dome. Entrances to the building are on either side, besides the grand entrances at each end, which latter are 110 ft. high and 32 ft. wide, opening into vestibules. A 60 ft. balcony extends entirely around the building, and the roof, of glass, is 100 ft. from the floor. Total cost of the structure is estimated at $350,000.

Electricity.—Van Brunt & Howe, architects, Kansas City.

Carpentry and ironwork, Arthur Johnson & Bros	$164,444
Exterior covering, Parke & Bates	85,000
Roof, James A. Miller & Bro.	22,100
Other items	19,992
Total	$291,536

This building, 700 by 350, will be 60 ft. high, and one of the handsomest of the central group, having four entrances, the main one facing south.

Manufactures.—George B. Post, architect, New York.

Ironwork on dome, King Iron Bridge and Mfg. Co.	$34,600
Exterior covering, Smith & Camp	173,000
Carpentry and ironwork, Agnew & Co.	450,892
Painting and glazing, W. H. Stubbings Co.	23,746
Roof, James A. Miller & Bro.	119,142
Other items	29,875
Total	$831,255

Woman's Building.—Sarah G. Hayden, architect, Boston.

Carpentry and ironwork, Steinmetz & Ellenberger	$52,587
Other items	45,160
Total	$97,747

Horticulture Building.—W. L. B. Jenny, architect, Chicago.

Ironwork on dome, Probst Construction Co.	$30,140
Exterior covering, Cudahy, Nelson & Vanderbergen	47,000
Carpentry work, McArthur Bros.	90,500
Roof, James A. Miller & Bro.	43,386
Other items	15,861
Total	$226,887

The Horticultural Building is in three pavilions, connected by front and rear curtains, forming two courts, each 88 × 270. The center pavillion, 187 ft. in diameter and 113 ft. high, with a crystal dome, will contain the tallest palms, bamboos and tree ferns procurable. Each pavilion has a gallery, those in the two ends being utilized for cafés, having arcades on both sides, from which views of the grounds may be obtained. The exhibits requiring extra height will occupy the rear curtains, which are covered with glass roofs close to the plants.

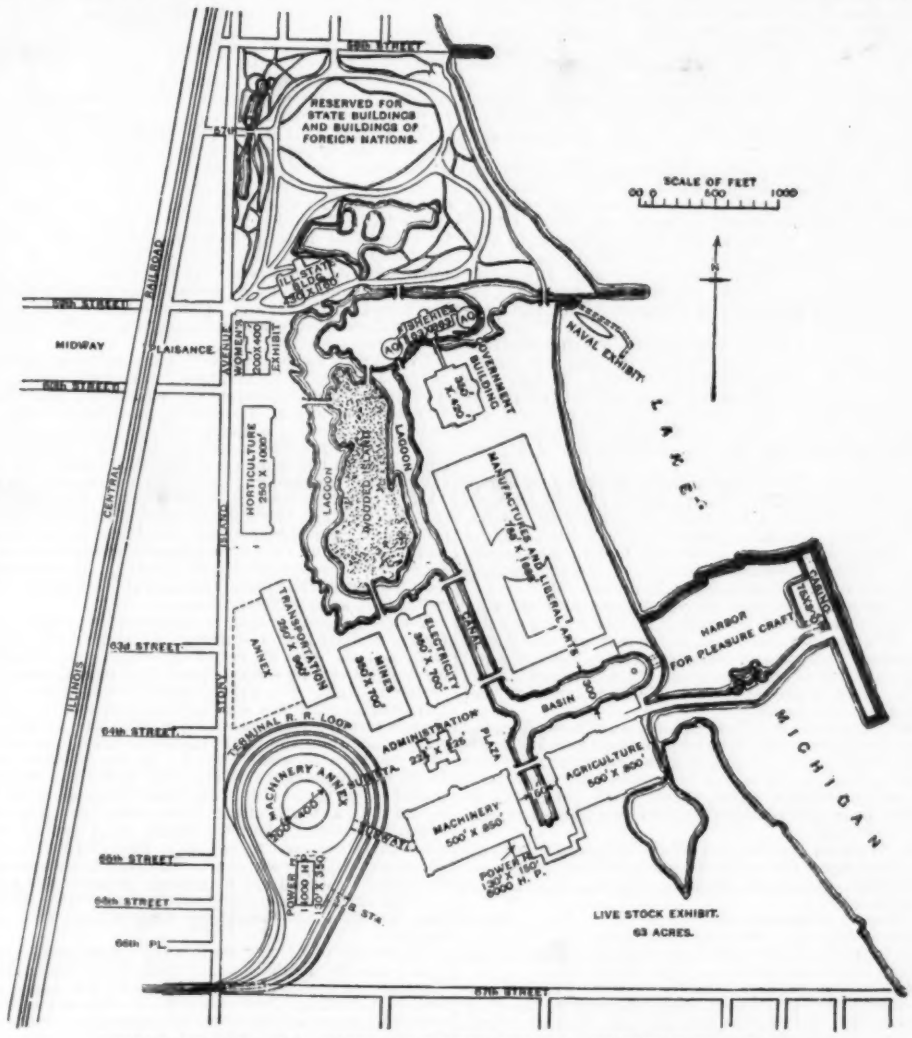
Transportation.—Adler & Sullivan, architects, Chicago.

Carpentry work, Goldie & Sons	$117,500
Exterior covering, Phillipson Decorative Co.	43,557
Roof, Smith & Cade Co.	30,580
Other items	12,471
Total	$204,108

The main building of the transportation exhibit measures 960 ft. front by 256 ft. deep; from this will extend westward to Stoney Island avenue a triangular annex covering about nine acres, and consisting of one story buildings, 64 ft. wide, set side by side. As there will be a railroad track every 16 ft., and as all these tracks will run east and west, these annex buildings may be used to exhibit an entire freight or passenger train coupled up with its engine. It is likely that the display of locomotive engines will be great.

Administration Building.—R. M. Hunt, architect, New York.

Carpentry work, Steinmetz & Ellenberger	$102,841
Ironwork on dome, Mt. Vernon Bridge Co.	55,000
Exterior covering, Smith & Crimp	111,000
Other items	25,491
Total	$294,232



THE SITE OF THE COLUMBIAN WORLD'S FAIR.

Architecturally this is considered the gem of all the buildings. It consists of four pavilions 84 ft. square, one at each of the four angles, the central dome being 120 ft. diameter and 260 ft. high. The entrances are in a recess in the center of each façade. Externally the design is in three principal stages—the four pavilions (65 ft. high) corresponding to the surrounding buildings; next a continuation of the central rotunda, of the same height and 175 ft. square; and the third, the base of the dome, 40 ft. in height and octagonal, from which the dome itself rises.

Agricultural.—McKim, Mead & White, architects, New York.

Carpentry work, W. Mavor	$244,450
Painting and glazing, Reilly & Barker	49,243
Exterior covering, J. Eastman	87,000
Roof, W. B. White	82,943
Total	$463,636

This building is to be one of the finest structures, and is nearly surrounded by lagoons. It measures 800 × 500 ft., and its main features are its five pavilions, those on the corners being 64 × 48 ft. square. The main entrance, 60 ft. wide, is on the north, and leads into a vestibule 30 ft. deep by 60 ft. wide. The rotunda is 100 ft. in diameter and 130 ft. high. There are eight lesser entrances 20 ft. wide, and the roof is principally of glass.

The main machinery building measures 850 × 500 ft. There will be traveling cranes running from end to end of the building. These will be useful in moving machinery, and when the exposition opens, platforms will be placed on them for visitors. Steam power will

be used throughout this main building, and this steam will be supplied from a main power house adjoining the south side of the building. The machinery annex will be of wood. Its shape is peculiar. It is to be annular in form, the outer diameter being 800 ft. and the inner diameter 400 ft. The building will have a nave 100 ft. wide, with a 50 ft. wide lean-to in one story on the inside and a 50 ft. wide lean-to on the outside. Within the inner circle will be a park, in which visitors may rest. The annular form chiefly commends itself because a circuit electrical railroad can run continuously around the entire main nave, and passengers in it can thus see the entire exhibit without leaving the cars, and machinery can be easily moved by this means. The power will be transmitted by shafting crossing the building at each bay, with a motor at each shaft. Electrical power will be used in the annex and steam power in the main machinery building.

The several amounts mentioned above do not, of course, represent the entire cost of the respective structures. There will be necessary a large expense to cover lighting, furnishing water supply, plumbing, etc. The contract for the Fisheries Building will be let within a few days, and at intervals during the next month will follow contracts for other buildings.

The contract for the pier and breakwater has been let to Hiero B. Herr & Co. for $80,000. Shailer & Schniglau have been given the contract for the pier at which will be moored the imitation battle ship containing the government's naval exhibit. Numerous other contracts, large and small, have been let, some of which have already been fulfilled. Chief among these is that for grading, filling, and dredging. McArthur Bros. took that at $399,872. Another contract is the temporary railroad for construction purposes. Ties, F. B. Stone, $8,630, and Mueller & Raber, $8,500; iron and steel, Ajax Forge Co., $2,000; rails, Illinois Steel Co., $22,048; total, $41,178. A contract has been signed whereby the city of Chicago agrees to furnish the exposition with water at $20 per million gallons, the exposition company to advance $200,000 for the construction of pumping works, and the city, at the close of the exhibition, to own the works and refund the $200,000.

All of the great exposition buildings erected by the construction department are to have roofs of iron and glass. All of them are to have an exterior covering treated to represent marble, granite, or other stone. Quite a number of the States have planned to construct their buildings of permanent building materials, such as are found in their respective limits. Plans and specifications for a number of the State buildings, including that of Illinois, are completed and the contracts are about to be let.

The U. S. government has already let the contract for the construction of the imitation coast line battleship which will contain its naval exhibit. It has also called for bids for its main building, which is estimated to cost something like $400,000, and the contract will be let in August. For its buildings and exhibits the government made an initial appropriation of $1,500,000.

Following are the foreign nations and colonies which have officially decided to participate in the exposition: France, Great Britain, Germany, Spain, Japan, China, Mexico, Peru, Honduras, Salvador, Costa Rica, Colombia, Cuba, Guatemala, Jamaica, Chile, Nicaragua, Persia, Turkey, Denmark, Egypt, Ecuador, British Honduras, Russia, Hayti, Siam, Trinidad—27.

The important matter of regulations and rates for the transportation of exhibits is now receiving a great deal of attention, and full arrangements are nearly completed. Important concessions have been secured from a number of transportation lines. As soon as all points are fully agreed upon, these arrangements will be published in detail.

The Central Traffic, Trunk Line, and New England associations have agreed to transport all articles to the exposition at regular rates, and to return the same free of cost, excepting in cases of horses and other valuable and fancy animals, upon which tariff rates will be charged in both directions and the established regulations observed.

The Western Traffic and Transcontinental associations have agreed to make the same concessions as have the Eastern associations, and make no exception in case of live stock.

A meeting of representatives of the various transatlantic steamship lines has been called in New York, and it is expected that a reduced rate on articles for exhibition will be agreed to.

Negotiations have been under way by which an entrance into the fair grounds might be had by the B. & O. Railroad. At present the only line having tracks into the grounds is the Illinois Central, which runs along the west side and switches in at the southwest corner. These main tracks are also used by the Michigan Central and the "Big Four." The directory took up the matter of trying to lease property south of the fair site sufficient for a 50 ft. right of way down to the B. & O. present tracks. This property is very valuable, and on account of pending deals in one or two cases there has been a reluctance on the part of the holders to granting the roads the right to cross. This lease to the directory has finally been obtained, however, for a nominal sum, and it now remains for the proposition to be accepted by the Baltimore and Ohio on condition that it allow all other roads to use the tracks for an entrance. The main lines of the Pennsylvania and Lake Shore roads run within a short distance of this corner of the park; also the Rock Island, the Western Indiana, and the Belt Line run into South Chicago, and will, therefore, be able to make good connections through these tracks, and, as the Belt Line taps all the roads entering the city, it will give those from the West and North an opportunity for switching trains directly to the exposition, thus insuring what has been contended for so long—equal advantages and ample railroad facilities for exhibitors from all directions.

The transportation committee has reached an agreement with the Illinois Central regarding the rate to be charged for handling freight for exhibits from junction points, within the city, to the exposition ground, of three cents for 100 pounds, subject to this condition: that, where the Illinois Central receives the cars properly sealed, and delivers them to the exposition grounds, the Exposition Company shall receipt for them, and shall relieve the Illinois Central of any liability for any shortage below the bill of lading or for any damage in transit; or, in other words, the Exposition Company undertakes to insure shipments against such loss.—*Railroad Gazette.*

SOME APPLICATIONS OF PHOTOGRAPHY.*

ONE of the subjects to which I propose to invite your attention this evening is the application of instantaneous photography to the illustration of certain mechanical phenomena which pass so quickly as to elude ordinary means of observation. The expression "instantaneous photography" is perhaps not quite a defensible one, because no photography can be really instantaneous—some time must always be occupied. One of the simplest and most commonly used methods of obtaining very short exposures is by the use of movable shutters, for which purpose many ingenious mechanical devices have been invented. About two years ago we had a lecture from Prof. Muybridge, in which he showed us the application of this method—and a remarkably interesting application it was—to the examination of the various positions assumed by a horse in his several gaits. Other means, however, may be employed to the same end, and one of them depends upon the production of an instantaneous light.

It will obviously come to the same thing whether the light to which we expose the plates be instantaneous or whether by a mechanical device we allow the plate to be submitted to a continuous light for only a very short time. A good deal of use has been made in this way of what is known as the magnesium flash light. A cloud of magnesium powder is ignited, and blazes up quickly with a bright light of very short duration. Now I want to compare that mode of illumination with another, in order to be able to judge of the relative degree of instantaneity, if I may use such an expression. We will illumine for a short time a revolving disk, composed of black and white sectors; and the result will depend upon how quick the motion is as compared with the duration of the light. If the light could be truly instantaneous, it would of necessity show the disk apparently stationary. I believe that the duration of this light is variously estimated at from one-tenth to one-fiftieth of a second; and as the arrangement that I have here is one of the slowest, we may assume that the time occupied will be about a tenth of a second. I will say the words one, two, three, and at the word three Mr. Gordon will project the powder into the flame of a spirit lamp, and the flash will be produced. Please give your attention to the disk, for the question is whether the present uniform gray will be displaced by a perception of the individual black and white sectors. [Experiment.] You see the flash was *not* instantaneous enough to resolve the gray into its components.

I want now to contrast with that mode of illumination one obtained by means of an electric spark. We have here an arrangement by which we can charge Leyden jars from a Wimshurst machine. When the charge is sufficient, a spark will pass inside a lantern, and the light proceeding from it will be condensed and thrown upon the same revolving disk as before. The test will be very much more severe; but severe as it is, I think we shall find that the electric flash will bear it. The teeth on the outside of the disk are very numerous, and we will make them revolve as fast as we can, but we shall find that under the electric light they will appear to be absolutely stationary. [Experiment.] You will agree that the outlines of the black and white sectors are seen perfectly sharp.

Now, by means of this arrangement we might investigate a limit to the duration of the spark, because with a little care we could determine how fast the teeth are traveling—what space they pass through in a second of time. For this purpose it would not be safe to calculate from the multiplying gear on the assumption of no slip. A better way would be to direct a current of air upon the teeth themselves, and make them give rise to a musical note, as in the so-called siren. From the appearance of the disk under the spark we might safely say, I think, that the duration of the light is less than a tenth of the time occupied by a single tooth in passing. But the spark is in reality much more instantaneous than can be proved by the means at present at our command. In order to determine its duration, it would be necessary to have recourse to that powerful weapon the revolving mirror; and I do not, therefore, propose to go further into the matter to-night.

Experiments of this kind were made some twenty years ago by Prof. Rood, of New York, both on the duration of the discharge of a Leyden jar and also on that of lightning. Prof. Rood found that the result depended somewhat upon the circumstances of the case, the discharge of a small jar being generally more instantaneous than that of a larger one. He proved that in certain cases the duration of the principal part of the light was as low as one twenty-five-millionth part of a second of time. That is a statement which probably conveys very little of its real meaning. A million seconds is about twelve days and nights. Twenty-five million seconds is nearly a year. So that the time occupied by the spark in Prof. Rood's experiment is about the same fraction of one second that one second is of a year. In many other cases the duration was somewhat greater; but in all his experiments it was well under the one millionth part of a second. In certain cases you may have multiple sparks. I do not refer to the oscillating discharges of which Prof. Lodge gave us so interesting an account last year; Prof. Rood's multiple discharge was not of that character. It consisted of several detached overflows of his Leyden jar when charged by the Rhumkorff coil. One number mentioned for the total duration was one six-thousandth part of a second; but the individual discharges had the degree of instantaneity of which I have spoken.

It is not a difficult matter to adapt the electrical spark to instantaneous photography. We will put the lantern into its proper position, excite the electric sparks within it, causing them to be condensed by the condenser of the lantern on the photographic lens. We will then put the object in front of the lantern condenser, remove the cap from the lens, expose the plate to the spark when it comes, and thus obtain an instantaneous view of whatever may be going on. I propose to go through the operation of taking such a photograph presently. I will not attempt any of the more difficult things of which I shall speak, but will take a comparatively easy subject—a stream of bubbles of gas passing up through a liquid. In order that you may see what this looks like when observed in the ordinary way, we have arranged it here for projection upon the screen. [Experiment.] The gas issues from the nozzle, and comes up in a stream, but so fast that you cannot fairly see the bubbles. If, however, we take an instantaneous picture, we shall find that the stream is decomposed into its constituent parts. We arrange the trough of liquid in front of the lantern which contains the spark making apparatus—[Experiment]—and we will expose a plate, though I hardly expect a good result in a lecture. A photographer's lamp provides some yellow light to enable us to see when other light is excluded. There goes the spark; the plate is exposed, and the thing is done. We will develop the plate, and see what it is good for; and if it turns out fit to show, we will have it on the screen within the hour.

In the meantime, we will project on the screen some slides taken in the same way and with the same subject. [Photograph shown.] That is an instantaneous photograph of a stream of bubbles. You see that the bubbles form at the nozzle from the very first movement, contrasting in that respect with the behavior of jets of water projected into air (Fig. 1).

FIG. 1.

The latter is our next subject. This is the reservoir from which the water is supplied. It issues from a nozzle of drawn-out glass, and at the moment of issue it consists of a cylindrical body of water. The cylindrical form is unstable, however, and the water rapidly breaks up into drops, which succeed one another so rapidly that they can hardly be detected by ordinary vision. But by means of instantaneous photography the individual drops can be made evident. I will first project the jet itself on the screen, in order that you may appreciate the subject which we shall see presently represented by photography. [Experiment.] Along the first part of its length the jet of water is continuous. After a certain point it breaks into drops, but you cannot see them because of their rapidity. If we act on the jet with a vibrating body, such as a tuning fork, the breaking into drops occurs still earlier, the drops are more regular, and assume a curious periodic appearance, investigated by Savart. I have some photographs of jets of that nature. Taken as described, they do not differ much in appearance from those obtained by Chichester Bell and by Mr. Boys. We get what we may regard as simply shadows of the jet obtained by instantaneous illumination; so that these photographs show little more than the outlines of the subject. They show a little more, on account of the lens-like action of the cylinder and of the drops. Here we have an instantaneous view of a jet similar to the one we were looking at just now (Fig. 2). This is

FIG. 2.

the continuous part; it gradually ripples itself as it comes along; the ripples increase; then the contraction becomes a kind of ligament connecting consecutive drops; the ligament next gives way, and we have the individual drops completely formed. The small points of light are the result of the lens-like action of the drops. [Other instantaneous views also shown.]

The pictures can usually be improved by diffusing somewhat the light of the spark with which they are taken. In front of the ordinary condensing lens of the magic lantern we slide in a piece of ground glass, slightly oiled, and we then get better pictures showing more shading. [Photograph shown.] Here is one done in that way; you would hardly believe it to be water resolved into drops under the action of a tremor. It looks more like mercury. You will notice the long ligament trying to break up into drops on its own account, but not succeeding (Fig. 3).

There is another with the ligament extremely prolonged. In this case it sometimes gathers itself into two drops (Fig. 4).

[A number of photographs showing slight variations were exhibited.]

The mechanical cause of this breaking into drops is, I need hardly remind you, the surface tension or capillary force of the liquid surface. The elongated cylinder is an unstable form, and tends to become alternately swollen and contracted. In speaking on this subject I have often been embarrassed for want of an appropriate word to describe the condition in question. But a few days ago, during a biological discussion, I found that there is a recognized, if not a very pleasant, word. The cylindrical jet may be said to become *varicose*, and the varicosity goes on increasing with time, until eventually it leads to absolute disruption.

There is another class of unstable jets presenting many points of analogy with the capillary ones, and yet in many respects quite distinct from them. I refer

* Friday evening discourse, delivered at the Royal Institution of Great Britain, on February 6, 1891, by Lord Rayleigh, F.R.S., Professor of Natural Philosophy, R. I.—*Nature.*

to the phenomena of sensitive flames. The flame, however, is not the essential part of the matter, but rather an indicator of what has happened. Any jet of fluid playing into a stationary environment is sensitive, and the most convenient form for our present purpose is a jet of colored in uncolored water. In this case we shall use a solution of permanganate of potash playing into an atmosphere of other water containing acid and sulphate of iron, which exercises a decolorizing effect on the permanganate, and so retards the general clouding

FIG. 3.

FIG. 4.

up of the whole mass by accumulation of color. [Experiment.] Mr. Gordon will release the clip, and we shall get a jet of permanganate playing into the liquid.

If everything were perfectly steady, we might see a line of purple liquid extending to the bottom of the trough; but in this theater it is almost impossible to get anything steady. The instability to which the jet is subject now manifests itself, and we get a breaking away into clouds something like smoke from chimneys. A heavy tuning fork vibrating at ten to the second acts upon it with great advantage, and regularizes the disruption. A little more pressure will increase the instability, and the jet goes suddenly into confusion, although at first, near the nozzle, it is pretty regular.

It may now be asked, "What is the jet doing?" That is just the question which the instantaneous method enables us to answer. For this purpose the permanganate which we have used to make the jet visible is not of much service. It is too transparent to the photographic rays, and so it was replaced by bichromate of potash. Here the opposite difficulty arises; for the bichromate is invisible by the yellow light in which the adjustments have to be made. I was eventually reduced to mixing the two materials together, the one serving to render the jet visible to the eye and the other to the photographic plate.

Here is an instantaneous picture of such a jet as was before you a moment ago, only under the action of a regular vibrator. It is *sinuous*, turning first in one direction and then in the other. The original cylinder, which is the natural form of the jet as it issues from the nozzle, curves itself gently as it passes along through the water. It thus becomes sinuous, and the amount of the sinuosity increases until in some cases the consecutive folds come into collision with one another. [Several photographs of sinuous jets were shown, two of which are reproduced in Figs. 5 and 6.]

FIG. 5.

FIG. 6.

The comparison of the two classes of jets is of great interest. There is an analogy as regards the instability, the vibrations caused by disturbance gradually increasing as the distance from the nozzle increases; but there is a great difference as to the nature of the deviation from the equilibrium condition, and as to the kind of force best adapted to bring it about. The one gives way by becoming varicose; the other by becoming sinuous. The only forces capable of producing varicosity are symmetrical forces, which act alike all round. To produce sinuosity we want exactly the reverse—a force which acts upon the jet transversely and unsymmetrically.

I will now pass on to another subject for instantaneous photography—namely, the soap film. Everybody knows that if you blow a soap bubble it will break—generally before you wish. The process of breaking is exceedingly rapid and difficult to trace by the unaided eye. If we can get a soap film on this ring we will project it upon the screen and then break it before your eyes, so as to enable you to form your own impressions as to the rapidity of the operation. For some time it has been my ambition to photograph a soap bubble in the act of breaking.

I was prepared for difficulty, believing that the time occupied was less than the twentieth of a second. But it turns out to be a good deal less even than that. Accordingly the subject is far more difficult to deal with than are those jets of water or colored liquids which

FIG. 7.

one can photograph at any moment that the spark happens to come.

There is the film, seen by reflected light. One of the first difficulties we have to contend with is that it is not easy to break the film exactly when we wish. We will drop a shot through it. The shot has gone through, as you see, but it has not broken the film; and when the film is a thick one, you may drop a shot through almost any number of times from a moderate height without producing any effect. You would suppose that the shot in going through would necessarily make a hole and end the life of the film. The shot goes through, however, without making a hole. The operation can be traced, not very well with a shot, but with a ball of cork stuck on the end of a pin and pushed through. A dry shot does not readily break the film; and as it was necessary for our purpose to effect the rupture in a well-defined manner, here was a difficulty which we had to overcome. We found, after a few trials, that we could get over it by wetting the shot with alcohol.

We will try again with dry shot. Three shots have gone through and nothing has happened. Now we will try one wetted with alcohol, and I expect it will break the film at once. There! it has gone!

The apparatus for executing the photography of a breaking soap film will, of necessity, be more complicated than before, because we have to time the spark exactly with the breaking of the film. The device I have used is to drop two balls simultaneously, so that one should determine the spark and the other rupture the film. The most obvious plan was to hang iron balls to two electro-magnets and cause them to drop by breaking the circuit, so that both were let go at the same moment.

The method was not quite a success, however, because there was apt to be a little hesitation in letting go the balls. So we adopted another plan. The balls were not held by electro-magnetism, but by springs (Fig. 8) pressing laterally, and these were pulled off by

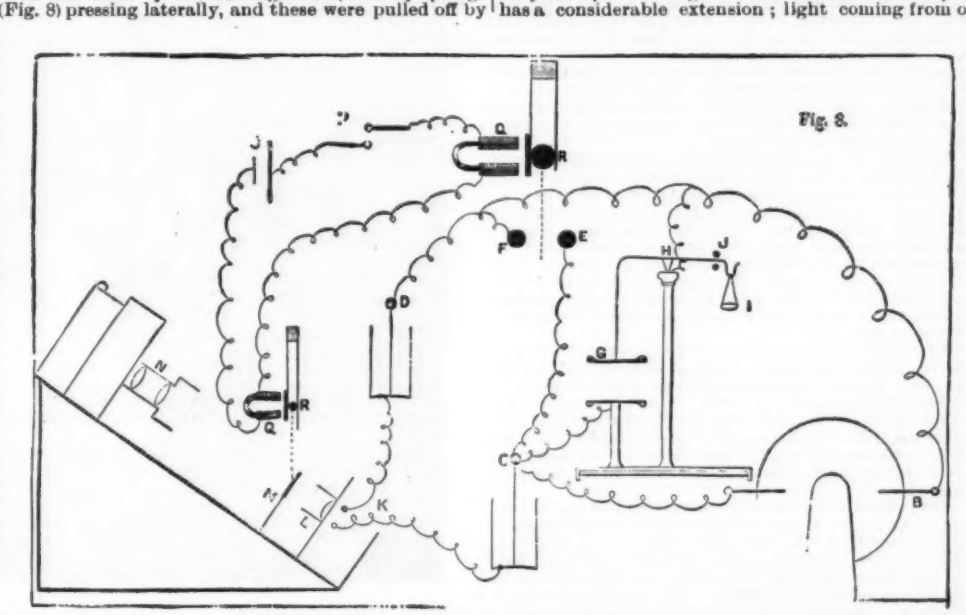


Fig. 8.

A, B. Electrodes of Wimshurst machine. C, D. Terminals of interior coatings of Leyden jars. E, F. Balls on insulating supports between which the discharge is taken. G. Attracted disk of electrometer. H. Knife edge. I. Scale pan. J. Stops limiting movement of beam. K. Sparking balls in connection with exterior coatings of jars. [These exterior coatings are to be joined by an imperfect conductor, such as a table.] L. Lantern condenser. M. Soap film. N. Photographic camera. O. Daniell cell. P. Key. Q. Electro-magnets. R. Balls.

electro-magnets. The proper moment for putting down the key and so liberating the balls is indicated by the tap of the beam of an attracted disk electrometer as it strikes against the upper stop. One falling ball determines the spark by filling up most of the interval between two fixed ones submitted to the necessary electric pressure. Another ball, or rather shot, wetted with alcohol, is let go at the same moment and breaks the film on its passage through it. By varying the distances dropped through, the occurrence of one event may be adjusted relatively to the other. The spark which passes to the falling ball is, however, not the one which illuminates the photographic plate. The latter occurs within the lantern, and forms part of a circuit in connection with the *outer* coatings of the Leyden jars,* the whole arrangement being similar to that adopted by Prof. Lodge in his experiments upon alternative paths of discharge. Fig. 8 will give a general idea of the disposition of the apparatus. [Several photographs of breaking films were shown upon the screen; one of these is reproduced in Fig. 7.]†

* In practice there were two sets of three jars each.

† The appearance of the breaking bubble, as seen under instantaneous illumination, was first described by Marangoni and Stephanelli, *Nuovo Cimento*, 1873.

This work proved more difficult than I had expected; and the evidence of our photographs supplies the explanation—namely, that the rupture of the film is an extraordinarily rapid operation. It was found that the whole difference between being too early and too late was represented by a displacement of the falling ball through less than a diameter, viz. ¼ inch nearly. The drop which we gave was about a foot. The speed of the ball would thus be about 100 inches per second; therefore the whole difference between being too soon and too late is represented by $\frac{1}{800}$ second. Success is impossible, unless the spark can be got to occur within the limits of this short interval.

Prof. Dewar has directed my attention to the fact that Dupré, a good many years ago, calculated the speed of rupture of a film. We know that the energy of the film is in proportion to its area. When a film is partially broken some of the area is gone, and the corresponding potential energy is expended in generating the velocity of the thickened edge, which bounds the still unbroken portion. The speed, then, at which the edge will go depends upon the thickness of the film. Dupré took a rather extreme case, and calculated a velocity of 32 meters per second. Here, with a greater thickness, our velocity was, perhaps, 16 yards a second, agreeing fairly well with Dupré's theory.

I now pass on to another subject with which I have lately been engaged—namely, the connection between aperture and the definition of optical images. It has long been known to astronomers and to those who study optics that the definition of an optical instrument is proportional to the aperture employed; but do not think that the theory is as widely appreciated as it should be. I do not know whether, in the presence of my colleague, I may venture to say that I fear the spectroscopists are among the worst sinners in this respect.

They constantly speak of the dispersion of their instruments, as if that by itself could give any idea of the power employed. You may have a spectroscope of any degree of dispersion, and yet of resolving power insufficient to separate even the D lines. What is the reason of this? Why is it that we cannot get as high a definition as we please with a limited aperture? Some people say that the reason why large telescopes are necessary is because it is only by their means that we can get enough light. That may be in some cases a sufficient reason, but that it is inadequate in others will be apparent, if we consider the case of the sun. Here we do not want more light, but rather are anxious to get rid of a light already excessive. The principal *raison d'etre* of large telescopes is that without a large aperture definition is bad, however perfect the lenses may be. In accordance with the historical development of the science of optics, the student is told that the lens collects the rays from one point to a focus at another; but when he has made further advance in the science he finds that this is not so.

The truth is that we are in the habit of regarding this subject in a distorted manner. The difficulty is, not to explain why optical images are imperfect, no matter how good the lens employed, but rather how it is that they manage to be as good as they are. In reality the optical image of even a mathematical point has a considerable extension; light coming from one point cannot be concentrated into another point by any arrangement. There must be diffusion, and the reason is not hard to see in a general way. Consider what happens at the mathematical focus, where, if anywhere, the light should all be concentrated. At that point all the rays coming from the original radiant point arrive in the same phase. The different paths of the rays are all rendered optically equal, the greater actual distance that some of them have to travel being compensated for in the case of those which come through the center by an optical retardation due to the substitution of glass for air; so that all the rays arrive at the same time.* If we take a point not quite at the mathematical focus, but near it, it is obvious that there must be a good deal of light there also. The only reason for any diminution at the second point lies in the discrepancies of phase which now occur; and these can only enter by degrees. Once grant that the image of a mathematical point is a diffused patch of light, and it follows that there must be a limit to definition. The images of the components of a close double point will overlap; and if the distance between the centers do not exceed the diameter of the represen-

* On this principle we may readily calculate the focal lengths of lenses without use of the law of sines (see *Phil. Mag.*, December, 1879).

tative patches of light, there can be no distinct resolution. Now their diameter varies inversely as the aperture; and thus the resolving power is directly as the aperture.

My object to-night is to show you by actual examples that this is so. I have prepared a series of photographs of a grating consisting of parallel copper wires separated by intervals equal to their own diameter, and such that the distance from center to center is $\frac{1}{70}$ inch. The grating was backed by a paraffin lamp and large condensing lens; and the photographs were taken in the usual way, except that the lens employed was a telescopic object glass, and was stopped by a screen perforated with a narrow adjustable slit, parallel to the wires.* In each case the exposure was inversely as the aperture employed. The first [thrown upon the screen] is a picture done by an aperture of eight hundredths of an inch, and the definition is tolerably good.

The next, with six hundredths, is rather worse. In the third case, I think that every one can see that the definition is deteriorating; that was done by an aperture of four hundredths of an inch, the next is one done by an aperture of three hundredths inch, and you can see that the lines are getting washed out. In focusing the plate for this photograph I saw that the lines had entirely disappeared, and I was surprised, on developing the plate, to find them still visible.

That was in virtue of the shorter wave length of the light operative in photography as compared with vision. In the last example, the aperture was only two and a half hundredths of an inch, and the effect of the contraction has been to wash away the image altogether, although, so far as ordinary optical imperfections are concerned, the lens was acting more favorably with the smaller aperture than with the larger ones.

This experiment may be easily made with very simple apparatus; and I have arranged that each one of my audience may be able to repeat it by means of the pieces of gauze and perforated card which have been distributed. The piece of gauze should be placed against the window so as to be backed by the sky, or in front of a lamp provided with a ground glass or opal globe. You then look at the gauze through the pin holes. Using the smaller hole, and gradually drawing back from the gauze, you will find that you lose definition and ultimately all sight of the wires. That will happen at a distance of about 4½ feet from the gauze. If, when looking through the smaller hole, you have just lost the wires, you shift the card so as to bring the larger hole into operation, you will see the wires again perfectly.

That is one side of the question. However perfect your lens may be, you cannot get good definition if the aperture is too much restricted. On the other hand, if the aperture is much restricted, then the lens is of no use, and you will get as good an image without it as with it.

I have not time to deal with this matter as I could wish, but I will illustrate it by projecting on the screen the image of a piece of gauze as formed by a narrow aperture parallel to one set of wires. There is no lens whatever between the gauze and the screen. [Experiment.] There is the image—if we can dignify it by such a name—of the gauze as formed by an aperture which is somewhat large. Now, as the aperture is gradually narrowed, we will trace the effect upon the definition of the wires parallel to it. The definition is improving; and now it looks tolerably good. But I will go on, and you will see that the definition will get bad again. Now the aperture has been further narrowed, and the lines are getting washed out. Again, a little more, and they are gone.

Perhaps you may think that the explanation lies in the faintness of the light. We cannot avoid the loss of light which accompanies the contraction of aperture, but to prove that the result is not so to be explained, I will now put in a lens. This will bring the other set of wires into view, and prove that there was plenty of light to enable us to see the first set if the definition had been good enough. Too small an aperture, then, is as bad as one which is too large; and if the aperture is sufficiently small, the image is no worse without a lens than with one.

What, then, is the best size of the aperture? That is the important question in dealing with pin hole photography. It was first considered by Prof. Petzval, of Vienna, and he arrived at the result indicated by the formula, $2r^2 = f\lambda$, where $2r$ is the diameter of the aperture, λ the wave length of light, and f the focal length, or rather simply the distance between the aperture and the screen upon which the image is formed.

His reasoning, however, though ingenious, is not sound, regarded as an attempt at an accurate solution of the question. In fact, it is only lately that the mathematical problem of the diffraction of light by a circular hole has been sufficiently worked out to enable the question to be solved. The mathematician to whom we owe this achievement is Prof. Lommel. I have adapted his results to the problem of pin hole photography. [A series of curves (*Philosophical Magazine*, February, 1891) were shown, exhibiting to the eye the distribution of illumination in the images obtainable with various apertures.] The general conclusion is that the hole may advantageously be enlarged beyond that given by Petzval's rule. A suitable radius is $r = 4\sqrt{(f\lambda)}$.

I will not detain you further than to show you one application of pin hole photography on a different scale from the usual. The definition improves as the aperture increases; but in the absence of a lens the augmented aperture entails a greatly extended focal length. The limits of an ordinary portable camera are thus soon passed. The original of the transparency now to be thrown upon the screen was taken in an ordinary room, carefully darkened. The aperture (in the shutter) was 0·07 inch, and the distance of the 12 × 10 plate from the aperture was 7 feet. The resulting picture of a group of cedars shows nearly as much detail as could be seen direct from the place in question.

INDIA ink is made from fine lampblack compacted and cemented with glue. The finest black is said to be derived from pork fat. The glue is made from buffalo hide.

* The distance between the grating and the telescope lens was 12 feet 3 inches.

AN INDIAN TODDY PALM—PHŒNIX SYLVESTRIS.

A FAMILIAR and perhaps, to some people, a monotonous feature in Indian scenery, particularly along the coast regions of Western India, are the groves of Phœnix sylvestris, one of the toddy palms, the commonest of the wild palms of the country, but a most valuable one to the natives. It is frequently seen in company with another noble palm, Borassus flabelliformis, the palmyra, and these, together with the cocoanut palm, which, in the neighborhood of Bombay, is cultivated in extensive plantations, comprise the chief elements of that striking tropical scenery which always impresses travelers from northern regions when they first see it. This Phœnix does not differ materially in aspect from the date palm of Egypt, P. dactylifera, which one sees on the way out, and my impression is that the date palm, as well as such Phœnixes as P. rupicola, tenuis, acaulis, canariensis, and possibly others, are but geographical forms of a widely distributed species, having a range almost as extensive as that of the cocoanut palm. Be this as it may, they all seem to me very much alike, and from my point of view produce the same effect, for in a natural grove of P. sylvestris one could select forms that to all appearances are identical with the species named. The palm now illustrated is not the only one that yields toddy, as there are several in India from which the enticing juice can be drawn, notably the palmyra, cocoanut and wine palm (Caryota urens), but in Guzerat the Phœnix yields the bulk of the enormous quantity of toddy that is consumed by the natives. Toddy drawing is, in fact, an important industry, and moreover a source of revenue to the government, as a tax is imposed upon every tree in full yield, and to which an official number is attached. A large plantation of Phœnix is a valuable property, for the owners assess their value at from five to fifteen rupees a tree. If a plantation is near a town or group of villages, or near a frequented highway, the drawing and distribution of toddy is always active and keeps several people busy. The mode of drawing is admirably shown in the picture. The toddy man is in the act of fixing a "chattie" at the mouth of a notch that has previously been made in the succulent part of the stem, the incision being made so that the descending sap trickles into the vessel, a few strips of reed being placed so as to conduct the juice more readily. The chatties are emptied morning and evening, and, as they hold a quart or more, a great quantity of sap is extracted from each tree during the season; and the loss tells materially on the health of the tree, so much so that if the extraction were to continue year after year, the tree would soon die from exhaustion. After a tree has been tapped for a full season, it is allowed to rest for two or three seasons, and that accounts for the intervals of the scars on the trunk, as may be seen in the picture where the man has his left foot and the scar lower down. The toddy drawer is possessed of surprising agility in climbing the perpendicular stems, which he does with the utmost ease, the only support being the rope he has fastened round his waist, which leaves his hands free. The fluid thus obtained is of the consistence of watered milk, and has a sweetish and to some Europeans an agreeable taste, while to others it is nauseating. When freshly drawn it is most refreshing, and to quaff a bowl of it when excessively thirsty is one of the pleasantest incidents in Indian life. When, however, it is allowed to ferment, which it quickly does, it is sour and unpleasant, and becomes as intoxicating as Scotch nectar, but in this state it obviously finds more favor with the natives. As a garden plant, the wild Phœnix is of great value for landscape effect when it occurs in natural groups, for in these you see all gradations of size, from the small seedling to the decrepit old trees, that have reached the length of their days, and lean leeward in a most picturesque way. The bluish gray green tint of a grove of Phœnix is perhaps too somber, but in a garden one can always introduce variety as a foreground, or intermixed in the group. It is a singular fact that the date-bearing palm does not thrive successfully in India, so as to produce edible fruit, and that of P. sylvestris is valueless as food, though the leaves and stems, and the fiber and bark thereof, are of value to the natives in various ways. The engraving is an admirable reproduction of a photograph by Messrs. Johnson & Hoffman, of Calcutta.—*W. Goldring, The Gardeners' Chronicle.*

PHŒNIX SYLVESTRIS, AN INDIAN "TODDY" PALM—A TODDY DRAWER AT WORK.

CELMISIA SPECTABILIS.

AT the fortnightly meeting of the Royal Horticultural Society on June 9, a very interesting plant was exhibited by Messrs. J. Veitch & Sons, of Chelsea, called Celmisia spectabilis. It was regarded with unusual interest, partly for the beauty of its daisy-like flowers and partly as representing a class of plants that are known by name only to gardeners. The Celmisias, for there are many of them, are all natives of New Zealand, where they are called by the appropriate name of mountain daisies. They dwell

high up on the mountains, and in the season of flowering give color to those regions with their large, bold, and symmetrically shaped blossoms, each like a magnified daisy, sweet to look upon, telling in a mass, and giving rise to hopes that the plants may be found of sufficient hardihood to weather the trials of an English winter and spring. About twenty-five species have been described, and not one can be called a weed, each and all possessing merit that places it in a good position among plants fit for the adornment of the garden. It is strange that the Celmisias, possessing characters that should render them valuable to the gardener, are practically a new revelation, new for the reason that one may hunt gardening dictionaries and works of authority upon such matters without obtaining information on this New Zealand family. It is placed, however, in the composite group in De Candolle's "Prodromus," published in the year 1836, where two species are described, and there is also reference to them in Hooker's "Flora of New Zealand," where a few kinds are figured. There is, however, a reason for the absence of the plants from English gardens, as they are very difficult to introduce from their native home, even by seeds, although at Kew efforts have been made to establish them there, but with small results. In the Royal Gardens two species are represented, one being the subject of the accompanying illustration, C. spectabilis, the other C. Lindsayi, while in 1890 nine plants of Celmisia were introduced alive, but never grew. A large specimen of C. spectabilis may be seen at Kew, but unfortunately it has not yet flowered, so that at present the hopes of this family making a permanent abode with us are not very strong. What is wanted is a plan by which they can be successfully imported from their mountain wilds in New Zealand; and as orchids, after repeated failures, were brought safely to our shores, so we may reasonably expect success with the Celmisias.

NEW ZEALAND ASTER—CELMISIA SPECTABILIS. (FLOWERS WHITE.)

The species with which we are most concerned here is C. spectabilis, and the award of a first-class certificate was well merited. A large basket of small plants were exhibited, and at once compelled attention, as being utterly unlike the usual run of things shown at the meetings. The plants were about six inches high, the leaves distinctly lanceolate, narrow, and covered on the under surface with a down-like felt, the upper surface silvery, and in excellent contrast to the flowers. Each is erect, carried on a short, sturdy peduncle, and about two inches across, the ray florets numerous, pure white, the disk yellow, and making up a full, handsome, symmetrical bloom. It is very free flowering, and the whole plant of a distinct, tufted character. The great point is whether it will stand the rigors of an English winter, and if it does then we shall have acquired a valuable acquisition for the outdoor garden. If it does not, however, exhibit this commendable trait, it may well take its place among plants suitable for growing in pots in the cool house. Those who wish for a Celmisia at once distinct and beautiful should not forget C. spectabilis, and the accompanying illustration shows its bold, handsome character better than mere description of its manifold charms. It is mentioned by Mr. Dutton in his interesting letter from New Zealand in the *Gardeners' Magazine*, July 18, page 433, as one of the treasures of the Christchurch Botanic Gardens; the flowers are described as being "as large as those of Chrysanthemum lacustre," but those illustrated were scarcely so large. Climatic differences easily account for this.—*The Gardeners' Magazine.*

APPLES.

By THOMAS MEEHAN.

THERE are described by various writers as having been at some time growing in America—all of which have had names given to them—some two thousand varieties of apples. As a matter of fact, no apple comes from seed exactly like its parent. Every seedling apple has, therefore, an individuality of its own, to a greater or less degree. The manner in which nature effects this variation has never yet been determined, though there is reason to believe the rhythmic growth has much to do with it. At each rest nutrition is diverted to other directions; in proportion to the duration of these rests other portions become developed. This is known as the law of acceleration or of retardation.

External circumstances, however, somewhat determine lines of growth. The warm sun brings forward the blossoms. The stamens, which prepare the fertilizing dust, develop rapidly under unusual warmth, while the pistil, which has the responsibility of bringing forth the fruit, takes its own time. In this way the stamens often mature the pollen in advance of the needs of the pistil. When the pistil is mature there is no pollen and hence no fertilization and no crop. The abundant seasons are when stamens and pistils mature contemporaneously. But even when the fruit is properly fertilized the tree has not stirred up nutrition enough the past season, and then the ground under the tree is stored with fallen miniature fruit.

Even the 2,000 kinds of apples now recognized make a trifling list compared to the apples of the past. No one knows where the apple was originally indigenous. It is common with garden authors to write that "by the skill of the pomologist the delicious apple has been developed from the wild crab." It is just as likely, from American experience, that the wild crab of the Old World is the degenerate escape from cultivated trees. We know that the ancient Greeks cultivated it, but, as the root of the word is the same in all, even the most barbaric tongues, there is little doubt of its being cultivated long before the dawn of modern civilization. Remains of what must have been very fine specimens of apples are found in the mud under spots where the lake dwellers of Switzerland had their cabins long before it was safe for human beings to found towns and villages on land. That it traveled with the white man from his early Asiatic home is much more likely than that nature, unaided by man, spread it all over the woods and wilds of Northern Europe.

Another good argument for its Asiatic origin lies in the fact that there is a closely related species of apple, Pyrus coronaria, truly indigenous to the Atlantic portion of the United States. During the past few years a remarkable correspondence has been discovered between the flora of this portion of our Union and that of Northern Asia. Many trees, shrubs, and flowers are absolutely identical, and many a scientific man would be willing to stake his reputation on the chance that, with this pretty native apple before him, there must be or have been more close Asiatic relations. Still, as an absolute fact, when asked where is the apple from, the honest answer is we do not know!

Among apples, as among living things, there are freaks—forms appearing in individual trees at the very extremes of normal conditions. A member of the State Board of Agriculture, in one of the Northern counties, has an apple tree that has never had a petal. No one would ever know that it was in blossom, yet it bears fruit abundantly. This shows that the pretty rosy parts of the flower, the petals, are non-essential to fruitfulness.

Some contend that the brilliant colors of the petals of flowers are given to attract insects, and arrange for cross fertilization. Others contend that the petals act as protectors of the undeveloped parts, while others believe that, to some extent, they have the function of leaves, and prepare food for the younger parts. Whatever it be, we see by this freak it is possible to have apples without them. Then there are seedless apples—apples with no core. There may be germs in the ovariums, and the germs may be properly fertilized by the pollen, but the power to absorb nutrition is weak and the ovaries die in infancy from sheer starvation. Having been once fertilized, the fleshy part we know emphatically as the apple grows on and matures, though the seed and core do not. Twins or even triplets are often seen in apples, as in so many other organisms, and just as in other organisms by independent germs coming into juxtaposition in an early stage of development, when the stronger body absorbs a considerable portion of the other.

Once in a while some tree in an orchard will take a notion to produce a different fruit from usual. Regularly producing round apples, the novelty may be a long apple, or it may differ in color or some other way. It is usual to refer this to the influence of some other pollen. But those who have made test experiments do not find any immediate effects on the fruit, though they do on the cotyledons or future seed leaves of the crossed fruit. On the other hand, we know that plants have a tendency to vary outside of any influence on the seed. The curled-leaved willow was raised from a branch which pushed out from a regular weeping willow, and in the same way many of the famous roses of the florists were not raised from seeds, but from branches, which, in some manner not yet explained, bore flowers wholly unlike those the plant had been in the habit of bearing. Human pride does not like to say it does not know, hence the intermixture of pollen is a popular explanation of this freak, but the wiser person risks "I do not know" as about the true state of the case.

Another freak is for an apple usually smooth to bear fruit with partially russeted skin. They have been seen with the upper half russet and the lower smooth, looking like huge acorns in their cups. Here we can get pretty near the direct cause, though we cannot yet understand how that cause is brought into operation. First, we must recall that an apple is only changed branches and leaves. Though changed, it will yet bear the characters of true branches. On the bark of young apple trees we may see, like needle punctures, small green spots, and we see the same on smooth apples.

These little dots are known as cork cells. On the bark they remain undeveloped for some ten years, when they proceed to work under the cuticle, and the old and useless bark is thrown off in thin scales. The rind of the apple is the analogue of the bark in the stems. The little dots or cork cells, much weaker in the rind than in the stem, start early with growth, and undermine the cuticle, thus giving the russet appearance. All this can be seen with a good lens. In the regular russet apples the tendency of the cork cells to form russet on the apple is very strong. This is all the difference between the true russet and those which are only occasionally so. Though we know this development of cork cells is the cause, science has not yet given us the slightest clew as to how these cork cells come to be set in motion—why they should not germinate so as to be destructive in less than ten years in the branch, and do it all in one year in the metamorphosed apple.

Why is one kind of apple red, another yellow, another green, even when ripe; or why a mixture of all these colors often in one? Again the truthful answer is, "We do not know." In flowers some have thought color was given in order to make them attractive to insects, the cross fertilization which sometimes occurs by such insect visits being supposed to be of some benefit to the race. Some pretty romancing stories have been written about this by the lively pens of even men distinguished in science. Such a reason for gay coloring could not apply to a fruit. It has been said by the same class of writers that an apple was made good to eat in order that the seed might be widely distributed. Most seeds have some special adaptation for distribution. A pine seed or a linden seed travels by wings spread to the wind; the sand burr adheres to the hair or wool of animals; the thistle or dandelion sails by its downy pappus to long distances, but the apple falls under the parent tree, and the seed can only grow after the apple has rotted away. And so, says the pretty theory, it was made grateful to man. He sends barrels of the fruit to long distances. Man eats the flesh and throws away the core, and on the spot where it falls an apple tree grows.

Surely, this is the fact, whether specially arranged to this end or not, but this will not account for the varying colors of the fruit. A Rhode Island Greening or a Newtown Pippin, green and unattractive, are scattered over the world as generously as the bright-colored Baldwin or Northern Spy.

We know a little of the manner in which color is brought about, and that is all. Oxidation of certain mineral elements, in connection with light, produces the various tints, but just why, in a striped yellow and red apple for instance, the mineral elements should not be uniform, and why there should be one kind in the line of the dark stripes and another in the line of lighter ones no one can tell.

We know also that the mysterious power we call life has something to say in the matter. An apple that may become highly colored when it is allowed to remain on the tree, will not color if plucked from its connection with its source of life on the tree.

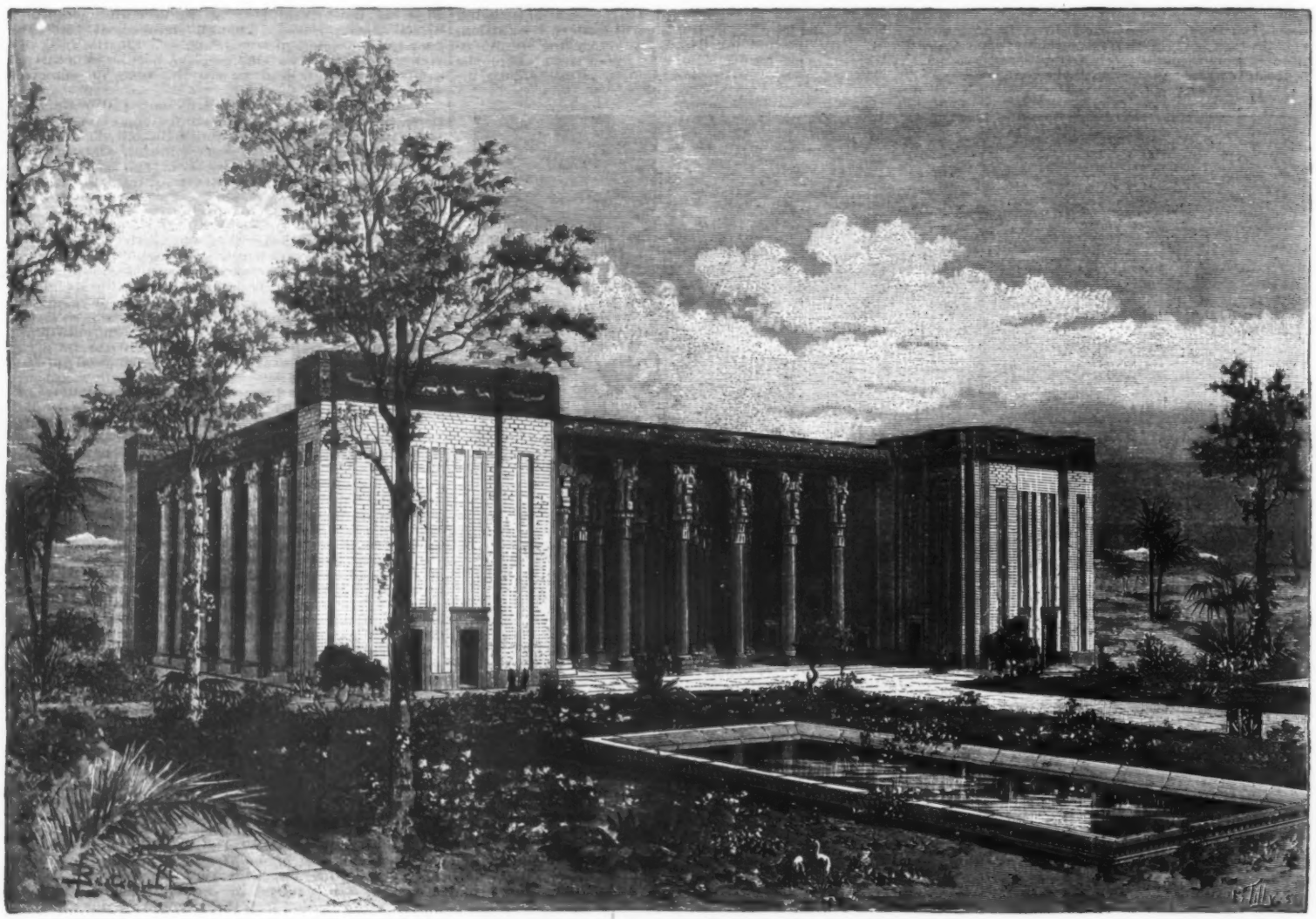
There has been one gain in our knowledge of the cause of color in flowers or fruits in a general way. If we brave the cold on a keen winter's day, the roses come to the cheek or the blue to the lips or nose. It is the same battle with the elements that brings color to flowers. The brightest and most brilliant colors are where the struggle for life is the greatest—that is to say, in the Arctics, on mountain tops, or on dry, barren deserts. It has even been found that flowers like flax, which in blossom present a sheet of light blue in a mild climate, have a deep azure when growing in Sweden, where the struggle of the plant with the elements is more severe.

In the tropics where everything is favorable to vegetation, there is a far greater proportion of species with insignificant flowers than in northern regions. The chief blaze of color of which writers speak as characterizing tropical scenery is due chiefly to orchids and other air plants, which have a struggle to live at all by clinging to trees, walls, or rocks, where they have to subsist chiefly on what they can gather from the air. The beautiful colors that characterize the autumn forests of severer regions are never seen there, but a dull, monotonous green persists in the forest scenery all the year round.

This has been found just as true of apples as of leaves and flowers, and was one of the great lessons taught by our great Centennial Exhibition. The apples of Canada beat the world for brilliant coloring. The collections became duller and duller as they came

from southern locations, till, reaching the collections from North Carolina, scarcely a bright one could be found in the very large collections that came from there. The same varieties would be larger, more juicy, and, in many respects, better than the northern ones, but these latter, though smaller, carried away always the popular vote for brilliancy and beauty. Undoubtedly, the more severe the struggle for life, the greater is the prevalence of brilliant color.

Just why some should be sweet and some sour is again another puzzle. The malic acid which gives it the sour taste seems to be in about the same proportion in the unripe as in the ripe apples; the difference in sweetness seems to arise from the change of starchy matter into sugar as the ripening process proceeds. But, though the chemist can tell us the exact elements that go to make sugar, he cannot make sugar for us. No power but that of the living plant can do it, and we are absolutely in the dark as to how the plant gets it done. Possibly the climate has some influence on the acting vital power, for the Rhode Island Greening, a sour apple in the Atlantic States, is a sweet apple on the Pacific—and the same apple will often have a part of the same fruit sweet on one side and sour on the other. These cases are generally attributed to some one in the past having split a branch through a bud, then fitting the sweet apple half to the half of the sour apple bud, and grafting the spliced graft. This is regarded as an ingenious after thought. Those who have directly gone and repeated the experiment have had no such result.



RESTORATION OF THE PALACE OF ARTAXERXES.

This chapter would not be complete without some reference to the apple of Paradise. All writers on the apple are expected to bring it in—but they start with it as a prelude, while we make it the peroration. It is one of the mysteries how this magnificent fruit got out of the Garden of Eden, following our first parents into a sinful world. If one might be permitted to formulate a theory, it was no doubt through the foresight of Eve. Adam probably threw away the core—the thoughtfulness of his wife undoubtedly led her to gather it up for the sake of the seed, wrap it up in a fig leaf, and take it with her when banished beyond the gates. However, we have the apple and are thankful.—*Phila. Ledger.*

THE APADANA OF ARTAXERXES MNEMON.

At the time of the opening of the museum of Persian antiquities at the Louvre, we told how the Dieulafoy mission had succeeded in reaching Dizfoul, a city situated not far from the site of Susa, one of the capitals of the ancient Persian empire. We also told how the mission, surmounting all difficulties, and despite the dangerous contact with superstitious and pilfering peoples who admitted the authority of the Shah of Persia only with great reluctance, had dug into the tumulus formed by the accumulation of the debris of palaces that had successively fallen down one over another, and how it had had the happy fortune to bring to France some pavements of Persian art of the times of Darius and Artaxerxes. This museum of Susiana has just been rendered complete by a restoration, on a reduced scale, of the Apadana or Throne Hall, constructed in the fifth century before Christ, under the reign of Artaxerxes Mnemon, the son of Darius II., the brother and conqueror of the younger Cyrus, who was killed at Cunoxa, despite the aid of a Greek contingent among which were Xenophon's ten thousand.

The Apadana formed a part of what Mr. Dieulafoy calls the acropolis or royal city of Susa. This city consisted, at the north, of a semicircular citadel; at the northwest, of a redoubt or collection of defenses called the dungeon; at the west, of the palace properly so called, and of the harem dwellings of the king, of his wives and of the court; and, finally, at the south, of the Throne Hall or Apadana.

These various constructions stood upon an artificial plateau of bricks and earth and overlooked the immense plain of Susiana, the aspect of which is given us by the panorama painted by Mr. Jambon in order to set off the reproduction of the Apadana. This entire collection of palaces and defenses was inclosed within three thick walls of unburned bricks rising one above the other from the exterior to the interior, flanked by battlemented towers and by machicolations situated very near each other and preceded by two moats. The three walls and their moats had a width of 295 feet and circumscribed an area of about thirty-three acres. One point to be remarked on an examination of a plan of the defensive system of the acropolis of Susa is that it already realized the divisions of the military architecture of our middle ages, with its towers, detours, flankings, etc., that rendered difficult both access to the place and the march of the assailant in case of surprise.

The Apadana, which our draughtsman has rendered in the landscape of the time, that is, standing in the midst of gardens planted with sycamores and palms, growing in the artificial soil of the acropolis, was appropriated to the official life of the king. Here he received ambassadors and gave his audiences, and, at certain times of the year, showed himself to the people. It had, as is shown by an inscription, replaced the Apadana of Darius I. (who was conquered at Marathon), which was burned and destroyed under the reign of Xerxes, who was vanquished at Salamis. The edifice formed a vast quadrilateral set with regard to the four cardinal points, and built upon a substructure 59 feet in height, measuring 354 feet in length by about 300 in width.

It consisted of four corner towers with high and thick walls of brick, presenting no opening except at the base, and crowned with a tile frieze from which stood out, in low relief, polychrome heraldic lions. Between the towers, to the east and west, extended two porticoes in two rows of six columns, separated from the Throne Hall by a wall containing free entrances, over which ran the great frieze of the archers called "the immortal," and of which the museum possesses beautiful examples. At the north the portico was similar, but was limited by a stronger relief of towers.

The south side, the one shown in our engraving, is, properly speaking, the true facade of the Apadana. The hall opens directly and the eye can take in the entire length of the seven naves, and the effect of those thirty-six columns, whether the view be a front or a three-quarter one.

On this side, the fluted columns, six in number, 69 feet in height and 6 feet in diameter at the base, are of very fine grained gray marble, brought from the mountains situated at about forty leagues from Susa. They start from a square base and terminate in a double superposed capital, the lower part of which consists of figures of the Egyptian lotus, with a crown of Ionic volutes, and the upper of a group of kneeling bulls, with gilded horns, eyes and feet. The columns of the porticoes start from a round base more ornamented than that of the columns of the front, but their capitals consist only of bulls' heads. This decoration of the capitals is a reminiscence of the arts of the Egyptians and Greeks, with whom the Persians of the time of the Achemenides were in constant relation; but the decorative *motifs* of them were modified according to the national instinct and symbolism. Upon the front capitals rest the rafters of the roof. Beneath, there extends a frieze of faience, with polychrome lions as at the top of the towers. This entire *ensemble* of seventy-two columns supported the ceiling of cedar rafters, weighing 2,600 tons, which had been dragged by men from Lebanon to Susa—a distance of 1,080 miles. This cedar ceiling was covered with a layer of earth, and this was protected by large terra cotta tiles with joint covers of the same material. The other columns of the front and the openings of the porticoes were closed by tapestry veils moved by systems of poles and cordages. The floor was paved with marble and covered with carpet; the area of the Throne Hall was 38,700 square feet, and that of the entire Apadana was more than 107,000 square feet.

The throne, which was of gold and ivory, stood at the northern extremity of the hall, hidden by hangings that were drawn apart for an instant, so that the people could get but a glimpse, in his mysterious and royal pomp, of the king of kings, or the great king, as the inscriptions preserved in the museum call him.

Such was this Throne Hall of the Achemenidian sovereigns, restored by the study of various substructures, such as those of the debris brought to light by Mr. Dieulafoy, and by a comparison of what still exists with the texts of Greek authors. In order to produce works of such grandeur, and to remove masses of such bulk, and carry them from such a distance, the Persian architects had at their disposal nothing but manual labor; but where, for one stress, we use a hundred weight of coal, they, for a like stress, perhaps used up the life of one man.—*L'Illustration.*

Artificial Fuel.—By J. Lundstrom, Stockholm.—The blocks of fuel are prepared by mixing the small coal produced in breaking anthracite with an adhesive paste made of finer coal, coal dust, peat, sawdust, etc., and a solution of silicate of soda; the mixture is then moistened with a solution of common salt containing 5 to 50 per cent of calcium chloride in order to hasten solidification, pressed or moulded into suitable forms, and dried if necessary.

ASTRONOMICAL OBSERVATORIES AND WHAT IS DONE THERE.

By F. W. LEVANDER, F.R.A.S., etc.

THERE must be very few indeed of my readers who have never heard of an astronomical observatory, many may have seen one—they are not very common; but I suspect that only a comparatively small number have ever been inside one or have more than a vague notion of the work done therein. Our national observatory is so close to the metropolis that many of the inhabitants of the little village are acquainted with its outward appearance, but we are not all Londoners. Besides, those who do go to Greenwich to look at the observatory are obliged to content themselves with gazing at the clock, the twenty-four hour dial of which being inserted in one of the walls is visible to the public, or getting some information as to the height of the barometer, or comparing their linear measures with the few copies of imperial standards on the outer wall.

Their attention may, too, have been called to the various domes, one or more of which, or the great drum itself, may have a slit open to the sky, and they may have been told that "astronomers were at work," with which somewhat indefinite statement they have gone away content. Nor, indeed, would they be enabled to satisfy any innate curiosity further, for without powerful credentials no one is allowed within the observatory itself. The stranger is, ordinarily speaking, no welcome guest there. In some foreign countries it is much easier to gain admittance to the interior of an observatory than is the case in our own country, and it is, perhaps, due in a considerable measure to this that we find around us such a lamentable ignorance—I speak advisedly, and from long experience—of even the commonest facts respecting the heavenly bodies, not to mention those which concern our own earth. The study of nature, the inquiring into those causes which are found to produce order out of apparent disorder, the harmonious obedience to which is erroneously referred to the *laws of nature*, must have an elevating effect on the minds of all who pursue this course aright, whatever branch of science is taken up. Astronomy presents us with a view of the workings of nature on the grandest scale; he who can survey the heavens on a clear night without some noble thoughts entering his breast must indeed be earthly. The more one studies the heavens, the greater must be one's admiration of the works of the Great Architect of the Universe.

An astronomical observatory may be briefly defined to be a place where astronomers observe the heavens by means of special instruments. I purpose to describe somewhat minutely such a place, and the various instruments and appliances to be found there, as well as some of the wonders of the heavens as seen by their aid, and to note the more important discoveries that have been made at various times in connection with the science of astronomy.

The chief instrument employed is, of course, a telescope, that is, a device by which distant objects may be brought apparently nearer to us, so that we may be enabled to scrutinize them with greater minuteness. Most people are acquainted with the outward appearance of a telescope, but its interior arrangements are probably a mystery to them. It may, therefore, not be lost time if we briefly consider its history and examine its construction. There are two sorts of telescopes, the one called refracting, the other reflecting. Of these the older form is the refractor. The credit of its discovery seems to lie between three persons, named respectively Henry Lipperhey, Zacharias Jansen and James Metius, who lived in the very early years of the seventeenth century. One or other of these accidentally noticed that by holding a concave glass near the eye and at the same time placing a convex one farther off, but parallel to the first, distant objects appeared to be magnified. Galileo, who had heard of this remarkable discovery, constructed a somewhat similar instrument in 1609. Two years later Kepler described how a telescope could be formed by a combination of two convex lenses, but he did not practically prove his theory. Indeed it was not till about fifty years afterward that such instruments were employed generally in making astronomical observations. The early telescopes were of very small diameter, but astronomers are always asking for "more light." It must be remembered that the light received by an object glass, as the larger glass at that end of the tube farthest away from the eye is called, when compared with that received by another, varies as the squares of their respective diameters. In the many attempts that were made at different times to keep pace with the demand for larger instruments, some important drawbacks presented themselves. One was the great difficulty experienced in making the lenses of the proper shape, for the proper curvatures of their surfaces have to be determined mathematically, and the glasses ground to these curves and then polished.

Then, again, when object glasses of larger size were attempted (though this difficulty did not at first show itself), it was found almost impossible to obtain a glass disk that was homogeneous and free from streaks and other imperfections. A third difficulty was that met with in consequence of the phenomenon known as chromatic aberration. If we take an ordinary lens and look through it at a bright object, we shall find that all the outlines of the latter are fringed with different tints, commonly called the colors of the rainbow. Such an array of colors round a celestial object would naturally be a serious obstacle to any accurate observation.

It was not till 1729 that the difficulty of producing glasses which should show an image free from extraneous color was surmounted by Chester More Hall. Though he made several instruments of this description he did not publish his researches, and the credit of being the first to make an achromatic lens, that is, one which will show images of the objects viewed without the colored fringes, is assigned to John Dollond, thirty-one years later. From his experimental researches on light, an account of which will be found in the "Philosophical Transactions" of the Royal Society for the year 1758, Dollond found that the desired end could be gained by placing together two lenses, the one nearest the object to be viewed being made of crown glass, and having its surfaces convex, the other made of flint glass and concave surfaces. Many years, however, before the production of Dollond's object glasses, attempts were made to overcome the difficulties we have mentioned by using telescopes of a totally different construction.

Instead of viewing the object through a lens or lenses, the light proceeding from it was allowed to fall on a polished mirror, made of metal and ground to a particular shape. If we place a looking glass against the wall in the middle of a room, and, standing at one end of the room, look in the glass, we shall see reflected from it the objects that are at the other end of the apartment. If now we carefully measure the angle made by the surface of the glass and a line drawn from those objects to that part of the glass where they are seen, and that made by the same surface and another line drawn from our eye to the same point, we shall find these angles to be equal. To put it into technical language, the angle of incidence (that is, the angle at which the light falls) is equal to the angle of reflection. The same law holds good with all mirrors, whether their surfaces are flat or curved.

Consequently it was found that, by using curved mirrors, the light falling on such a one could be caused to be reflected in a direction not far removed from that of the line in which it originally fell. By using mirrors of proper curvature, all the light will be *reflected* to one point; whereas in the case of a lens the light which falls on it is *refracted*, or bent to one point. Hence arise the two names, reflector and refractor, as applied to telescopes. Whichever sort of telescope is employed, as the use of the mirror, or object glass, is merely to collect light and bring it to one point called the focus, the image there formed must be enlarged. This end is accomplished by means of a small lens, or combination of lenses, known as the eye piece. In the case of astronomical telescopes the eye piece usually consists of a tube containing two double convex lenses of different sizes; the larger of the two faces the object glass, and is called the field lens, the other, the eye lens.

These two glasses are so arranged as to be equivalent in use to a single lens, and we can, by a little calculation, find the focal length of the combination. Since the light-gathering power depends on the size of the object glass or mirror, it is, of course, always the same for a given instrument; but the amount of magnification depends upon the eye piece that is used, and is determined by dividing the focal length of the object glass or mirror by that of the eye piece. "Deep" eye pieces are those the focal length of which is short. The first person who actually made a reflecting telescope was Sir Isaac Newton, about 1670. The various forms of reflectors are known as the Newtonian, Gregorian, Cassegrainian, and Herschelian, thus perpetuating the names of their respective inventors. As regards the first three, the rays of light which fall on the mirror are reflected to a smaller polished surface, and thence to the eye piece, while in the Herschelian the small mirror is dispensed with, the observer's back being turned toward the object to be examined. The making and subsequent grinding of large object glasses or mirrors are matters of exceeding difficulty, and heavily tax the skill and patience of the artist. Yet the necessary knowledge has so far advanced that the mirrors and object glasses, having a diameter of six and three feet respectively, which have already been made, will probably be soon surpassed in size.

Having obtained an insight into the construction of a telescope, we must next consider how it can best be supported so that we may be able to do good work with it. It must be remembered that a somewhat inferior telescope on a good stand is far more serviceable than a better instrument on an inferior support. The most simple form of stand for an astronomical telescope is an arrangement in which the main tube is firmly screwed, near its center of gravity, to a somewhat long piece of metal—a cradle—which is attached by a joint to a vertical pillar. This pillar is fastened to a wooden or metal tripod, but its interior construction is of such a nature as to allow the upper jointed part to revolve at will. With such a stand the telescope will be capable of being moved in a horizontal, as well as in a vertical, direction, and, therefore, of being pointed to any part of the heavens we wish. Assuming that we are in possession of a telescope mounted on a stand so firm and steady that it will not allow the instrument to vibrate after being moved, and we are anxious to do some real work with it, on the first suitable night we set up our instrument in the garden. In our changeable climate we must not expect to be out very long before clouds come up or rain begins to fall; everything has to be hurriedly brought indoors. Then it is that the observer longs for an observatory, and if his means are commensurate with his zeal, no great length of time will elapse before he is in possession of what is not merely a luxury but an absolute necessity. Then, too, he will bethink him of a better mode of supporting his telescope; but a consideration of this we will defer for the present. Of observatories there are different sorts and sizes, ranging from the modest and inexpensive Berthon telescope house to that magnificent establishment lately completed, to which many an astronomer is directing his eager longings, the Lick Observatory.

Let us assume that by some fortunate chance we have been able to get within the charmed portals of a well-equipped observatory, and, for the better accomplishment of our design, that we have free ingress and egress at any hour of the day or night, and in addition that the director has the time at his disposal, as well as the inclination, to serve us in every possible way. Our first desire will doubtless be to see the largest instrument in the establishment. Certainly our own little instrument belongs to the same class, but its relationship to the monster now before us seems very distant; moreover, there is not the faintest similarity between our simple stand and the complicated arrangement by which the enormous tube is supported. Evidently there is a great deal to be learned here. Our mentor explains to us how the dome or drum over the instrument is worked. By pulling a rope a slight opening, a few feet wide, is made from horizon to zenith, and by pulling another rope or turning a winch the whole of the dome or drum is caused to revolve. The open part can thus be directed to any part of the sky. Some of these domes are of enormous size, yet they are so well balanced and their mechanism so nicely made that the apparently cumbrous mass can be easily moved by the expenditure of a very small amount of power. The mounting of the telescope rests on a solid mass of masonry or concrete, extending many feet below the surface of the earth, and entirely disconnected from the floor. This is done to obviate the effects of vibration, than which few things are more annoying to the astronomer. If really good work is to be done, the observer must be at his ease, his hands must be free, he must be able to look straight through his telescope without incurring a crick of the neck by having to twist himself about into all imaginable and unimaginable positions. We shall find various devices about the room to enable us to accomplish this very desirable end. There are chairs of the ordinary height but with sloping backs, and there are cunning arrangements by which the observer, without leaving his seat, can raise or lower it to any required height, move it in any direction, or alter the inclination of the back. In some observatories the floor itself can be raised or lowered at will.

Now, let us examine the instrument itself. Its mounting, as we said, in nowise resembles our simple stand; we are told that it is an equatorial. Who that has a telescope and an ordinary stand cannot recall some such experience as the following? He is eager to show an unscientific friend some celestial object—it may be Saturn, that wonderful planet with his belts, rings and moons, a really good view of which is so seldom obtained in England. He gets it into the field of view—as that part of the sky visible in the telescope is called—and tells his friend to look. His friend, after various ineffectual efforts, gets his eye into the proper position, glances up the tube and immediately exclaims, "It is gone!" *It* has not gone, but all the while that he has been performing his evolutions the earth has been steadily rotating on its axis as usual, carrying with it the telescope and the would-be observer. The telescope is slightly moved, another attempt made and this time, perhaps, with success. Saturn, with all his retinue, passes majestically across the field of view. Every few seconds the position of the telescope has to be altered in a direction contrary to that in which the earth is moving, and, if the stand is not well made, every movement will be attended with vibration. Such a state of things will never do when long-continued, careful observations are to be made. It is to do away with such inconveniences that the equatorial or parallactic form of mounting was devised. Of this there are two sorts, known respectively as the English and the German pattern. The latter is the more generally met with, since with it the telescope can be easily pointed to any part of the sky, which is hardly the case with the English form. If we watch the motion of a heavenly body for a few hours, we shall find that the path it appears to follow is part of a circle. Let us note, for instance, the middle one of the three stars forming the belt of Orion, sometimes called the Tailor's Yard, and watch it from its rising. We shall see that the path it describes, as it gets higher in the heavens, is not vertical. Now, let us try to follow it with a telescope mounted on a simple stand. We shall very soon find that we are unable to keep the star in the field of view with either a horizontal or a vertical movement, but we must combine the two. If, however, we tilt the pillar of the stand in a northerly direction until it points to the north pole—very near which is the pole star—we shall be able to follow the star in question by means of one movement only, but that neither horizontal nor vertical. Let us try the experiment with any other star, and we shall meet with equal success; the middle star in Orion's belt was selected simply because it is close to the equator, and for that reason somewhat better for our purpose. We have, in fact, constructed a simple equatorial stand.

But still something more is needed. We want our hands to be free, and not engaged in constantly imparting movement to the telescope. Skillful mechanicians again come to our aid, and, by means of clockwork attached to the telescope, the whole instrument is kept moving at exactly the rate required to counteract the motion of the earth. With this addition to our equatorial, let us turn the telescope to any heavenly body that we are desirous of scrutinizing, and it will remain, as if it were fixed, in the center of the field of view, so long as the clockwork is kept going. Clockwork of this description has now been brought to a very high degree of perfection. A similar arrangement is sometimes adopted for the purpose of moving the floor round.

Attached to the main tube of the telescope we notice one or more smaller ones, called finders. On looking through one of these we shall find a cross of fine wires dividing the field of view accurately into four quadrants. When any object is seen at the center of this cross, it will be found also in the center of the field of view of the large telescope, for the two instruments are placed exactly parallel to each other. With a large telescope it is very difficult to point accurately to an object; even when the aperture is only a very few inches, a finder is an absolute necessity. There are, also, many other articles attached to the great tube, the various uses of which are at present a mystery to us.

Having pursued our examination thus far, we are naturally anxious to see some of the wonderful sights in the heavens that we have heard of. We, therefore, crave and gain permission to spend some hours, both by night and by day, at different times of the year, within the observatory with our guide. We shall most likely be told not to choose nights, however clear, when the wind is easterly. Clear definition is never obtained when the air is very dry. In our climate the best nights for astronomical observations are in September, and the early hours of the morning are always superior to the late hours of the evening. Finding ourselves beneath the dome, a patch of starlit sky is exposed to our view by the opening of the shutter. When we had our small telescope in the garden, we could easily recognize the familiar constellations and turn the instrument to the stars we wished to examine, but now we have only a limited amount of sky room within view, and an element of difficulty is thereby introduced. The finding of a particular object, unless it be the sun or moon, is not a matter to be easily accomplished by the mere shifting of the telescope. If we wish to describe the position of any place on the surface of the earth, we state its latitude and longitude, that is, we say that the place is situated on a certain imaginary line, so many degrees north or south of, and parallel to, the equator, at a point where it is crossed at right angles by another imaginary line so many degrees east or west of the meridian of Greenwich. So it is with the stars; we must have their ap-

parent places indicated by the intersection of two imaginary lines at right angles to each other. Instead of latitude and longitude, we adopt declination and right ascension. By north or south declination is meant distance north or south of the celestial equator (which is an extension into space of the terrestrial equator), expressed in degrees, minutes, and seconds. As a substitute for declination, north polar distance (abbreviated N. P. D.) is sometimes employed, being the distance, also in degrees, minutes and seconds, of a celestial body from the North Pole. We reckon terrestrial longitude from the first meridian, an imaginary line passing from north to south through a certain room in the observatory of Greenwich, but for a starting point of right ascension we must take something in the heavens. That which is adopted is called "the first point of Aries." About two thousand years ago the sun used to enter the constellation Aries, one of the twelve signs of the zodiac, at about March 20, the time of the vernal equinox, and it was at about the same date that the first catalogue of the stars was made by Hipparchus. This, therefore, was a convenient starting point, and though what is called "precession of the equinoxes" has caused the sun's position to be other than what it was at the period above mentioned, the mode of reckoning has been retained. Right ascension (abbreviated R. A.) is reckoned from west to east, either in hours, minutes, and seconds of time, or in degrees from 0° to 360°.

Our friend, wishing to show us some particular object, hunts up its place in a star catalogue or in the Nautical Almanac, and then explains to us some of the hitherto mysterious appendages to the telescope. He bids us notice that the polar axis (the counterpart of the tilted pillar of the simple stand) has, at its upper hand, another hollow axis, called the declination axis, attached to it at right angles. To one end of the tube, moving partly inside the latter, the telescope is firmly fixed, to the other a mass of metal, which acts as a counterpoise and tends to keep everything steady. Near this counterpoise is fixed at right angles to the axis a metal circle, of which either the edge or the face is very accurately divided into degrees and their subdivisions. A very ingenious contrivance, invented in 1631 by Pierre Vernier, and called by his surname, enables one to determine the value of spaces much smaller than those actually engraved on the circle, thereby considerably lessening the difficulty and cost of workmanship. These divisions are read by one or more microscopes conveniently placed. The graduation on the circle is arranged in four quarters or quadrants from 0° to 90° each, and the line joining 0° and 0° points to the celestial equator. The verniers, for there are usually two, placed diametrically opposite each other, being attached to, and therefore moving with, the tube which passes through the hollow declination axis, and to the other end of which the telescope is attached, can be set to any part of the declination circle. By this means the telescope is set to the declination of the object sought. At the lower end of the polar axis are two other circles, one of which is movable, with their verniers and reading microscopes; these are divided into hours, minutes, etc. The sidereal time is noted, one of the R. A. circles is set to it, and the other to the R. A. of the object, the clockwork is set going, and we can now examine the object, whatever it be, at our ease. In the more complete form of equatorial the reading microscopes, for both declination and right ascension, have their eye-pieces at the eye end of the telescope.

(To be continued.)

CELLULOID.

M. DE LA ROYNE describes the composition, manufacture, and properties of celluloid in the following manner in the *Revue de Chimie Industrielle:*

Celluloid is not obtained by a single operation. A very thick collodion is first made, in which the ether is replaced by camphor, and which, therefore, contains pyroxyline or nitrocellulose, camphor, and alcohol; sometimes, and this is the method adopted in Germany, ether is also added. This collodion is brought to the consistency of a paste, slightly heated and rolled; the heat, which is gradually increased, removes the volatile solvents and the pyroxyline and camphor combine in a more intimate manner to produce a horny transparent substance.

A German chemist, who has made numerous experiments with celluloid, has expressed the opinion that the product is not the result of a true chemical combination, but of an action resembling that which takes place in leather. In support of this statement we quote the chemical composition of two different kinds of celluloid, as given by M. Bockmann:

	A.	B.
Pyroxyline	64·89	73·70
Camphor	32·86	22·79
Ash (coloring matter)	2·25	3·51
	100·00	100·00

The first of these analyses shows the composition of celluloid as made at Berlin; it is generally met with in commerce in the form of sticks. The second is of that made in London, which is usually found in plates of varying size.

The nitrocellulose itself can be made in various ways; either paper, cotton, or shavings can be employed. The cellulose is brought into glass vessels containing a mixture of one part of fuming nitric acid with two parts of sulphuric acid, and the temperature kept at about 22° C. The soaking continues from 5—20 minutes, according to the nature of the material. According to another process, 115 grms. of sulphuric acid of sp. gr. 1·84, and 93 grms. of nitric acid of sp. gr. 1·40 may be heated together to 80° in a porcelain dish. As much cotton as possible is immersed in this liquid, and after soaking for five minutes washed freely in water. The product thus prepared is completely soluble in alcohol.

M. Franchimont states that when paper is treated with a mixture of sulphuric acid and acetic anhydride, a colored liquid is formed which gives a precipitate with water. The powder thus formed, after washing in a large quantity of water and then with cold alcohol, dissolves in boiling alcohol and crystallizes out on cooling in needles or plates. This substance is almost insoluble in ether, dissolves in benzene, and melts at 212° C. It corresponds to the formula $C_{12}H_{14}O_{21}$, and is looked upon by M. Franchimont as a triglucoside containing eleven acetyl groups.

The pyroxyline, prepared as above described, is left for 24 hours in contact with 15—35 parts of camphor and 11 of alcohol of 90° strength; a gelatinous mass is thus obtained which is solidified by heat, the alcohol being driven off. This mass is usually rolled between metal cylinders heated by steam on the inside, the external surface being kept at about 60°, and this rolling is continued, the cylinders being gradually brought closer together until the sheet is about 12 mm. thick, and has the wished-for strength and consistency.

Crude celluloid is a horn-like transparent mass of a slightly yellowish color, and of sp. gr. 1·25—1·45. Heat softens it and renders it capable of taking impressions. At 90° it becomes very plastic and on further heating it becomes still softer, but when heated for some time at 140° the camphor volatilizes and the pyroxyline is left.

It readily kindles, and burns with a smoky flame like turpentine; it can be extinguished by vigorous blowing, but continues to disengage thick vapors of camphor (sometimes it burns with great rapidity and is extremely dangerous for some purposes; moreover, it softens with heat, a great disadvantage for many applications). It is not affected by percussion and cannot be fired even by fulminating caps.

Sulphuric acid rapidly decomposes celluloid on heating, while hydrochloric acid attacks it much less vigorously. Nitric acid slowly attacks it in the cold, very rapidly on heating, and the same is true of caustic soda. Acetic acid dissolves it, giving a solution from which water precipitates camphor and nitrocellulose. It is also soluble in ether, acetic ether, acetone, fatty oils, alcohol, and turpentine.

In order to imitate marble, ivory, or shell, the celluloid must be colored either uniformly or in stripes. This is done in the first case by introducing the coloring matter, usually mineral powders, oxide of zinc, salts of baryta, strontia, copper, lead, mercury, etc., while the mixture of nitrocellulose and camphor is being worked. In the second case pastes of the requisite shades are first prepared, which are rolled and placed in the moulds. The harmonious arrangement of colors depends entirely on the skill of the workmen.

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